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Task Analysis/Workload (TAWL) User's Guide: Version 4.0

April 1991

ARI Aviation R&D Activity at Fort Rucker, Alabama
Systems Research Laboratory

U.S. Army Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE
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Technical review by

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The Task Analysis/Workload (TAWL) methodology was developed to predict operator workload using the information produced from a task analysis of the system. Subsequently, the TAWL Operator Simulation System (TOSS) was written in Turbo Pascal to perform all the database management and model execution functions needed to use the methodology on an IBM compatible computer. This user's guide contains a description of the TAWL methodology and instructions for generating a workload prediction model using the TOSS Version 4.0 software.

Part I of this guide presents a global overview of the TAWL methodology; each of the three major phases of the methodology (Task and Workload Analyses, Model Construction, and Model Execution) are described in detail. A glossary is provided to define the use of many of the terms. Part II presents step-by-step instructions on the use of the menu-driven Version 4.0 of the TOSS software. Examples of workload rating scales and TOSS output are provided to support the application of the methodology.

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Task Analysis/Workload (TAWL) User's Guide: Version 4.0

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Human Factors in Training
Operational Effectiveness

TASK ANALYSIS/WORKLOAD (TAWL) USER'S GUIDE: VERSION 4.0

CONTENTS

FOREWORD

The development of new and existing weapon systems will have an impact on the Army's manpower, personnel, and training requirements. Changes in the technology or manpower used in a system can have considerable impact on the workload of the operator(s). Because high operator workload can decrease system effectiveness, operator workload must be considered throughout the system design process.

Models have been developed to predict the operator workload in Army helicopters. The method used for creating these models is called the Task Analysis/Workload (TAWL) methodology. The TAWL Operator Simulation System (TOSS) has been developed to provide computer support for the methodology. The TAWL methodology is useful for assessing the effect of equipment design changes, mission changes, or manning changes on the workload of the system operator(s). It has been applied both to existing systems and in advance of system design.

This research product is a user's guide for the TAWL methodology and Version 4.0 of the TOSS software. The guide consists of two parts. Part I presents a global overview of the TAWL methodology, and Part II presents step-by-step instructions on the use of Version 4.0 of the TOSS software. The production of the TAWL User's Guide comes in response to increasing interest in the methodology's application to a broad range of Army systems. This interest emanates from industry, as well as from the Army.

This work was conducted at the U.S. Army Aviation R&D Activity, Fort Rucker, Alabama, under research task 1210, entitled "Reducing Operator and Maintainer Requirements in Next Generation Army." The Aviation Systems Command (AVSCOM), St. Louis, Missouri, sponsored the research under a memorandum of understanding entitled "Establishment of Technical Coordination between the U.S. Army Research Institute for the Behavioral and Social Sciences and AVSCOM," dated 10 April 1985.

In October 1990, the TAWL methodology and a demonstration of the TOSS software were presented at the 34th annual meeting of the Human Factors Society in Orlando, Florida. In addition, the user's guide and software have been provided to representatives of the Sikorsky Aircraft Company, Stratford, Connecticut; McDonnell Douglas Helicopter Company, Mesa, Arizona; Midwest Systems Research, Dayton, Ohio; Mitre Corporation, McLean, Virginia; and AT&T, Somerset, New Jersey.

Edgar M. Johnson

EDGAR M. JOHNSON
Technical Director

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Part I

Task Analysis/Workload (TAWL) Methodology

Introduction

This Task Analysis/Workload (TAWL) User's Guide contains a description of the methodology and instructions for generating a workload prediction model using Version 4.0 of the TAWL Operator Simulation System (TOSS). A TAWL workload prediction model is an analytical tool that generates detailed predictions of workload for up to four operators of an item of equipment (referred to as the system). The predictions are detailed with respect to time and type of task demands (e.g., visual, cognitive) placed on the operators of the system. The detail generated in the predictions is accomplished by developing and inputting a description of each operator's use of the system. The intended users, purpose of the user's guide, and overview of the guide is described in the following sections.

Intended Users

The TAWL methodology and the TOSS software are useful for the analysis of workload in situations where other measures of operator workload are impractical. Some examples of systems where direct measurement of operator workload are impractical include: systems that are under development, systems that are extremely dangerous or expensive to operate, systems that have a large number of different configurations, systems that have a large number of different uses, and systems where direct or indirect observation of the operators is not possible.

A TAWL workload prediction model can be used to evaluate or compare different systems during system acquisition. The methodology generates workload predictions with sufficient detail to be diagnostic of workload problems. For example, the TAWL methodology might predict that proposed changes to a system would result in higher visual workload. Whereas, if the workload is characterized by a single metric, the only conclusion that can be drawn is that the operator's workload has increased; however, the source of the increase (e.g., cognitive, auditory, visual) would remain unknown. The level of detail produced as a result of a TAWL analysis is difficult to approximate using other forms of workload measurement or analysis.

The methodology requires the identification of all aspects of the man-machine interface and produces a timeline of system use, annotated with the tasks performed by each operator. This information can be used by training system developers to design devices necessary to train selected system functions or tasks. It can be used to determine the amount of time that each subsystem in the system is used by the operator(s). It can also be used to manage the use of limited processing or storage in a computer system. For example, computer instructions and data necessary to perform certain functions might be loaded and available only when the user is expected to activate those functions. Thus, computer processing power and storage could be saved because all functions would not be available at all times.

The TAWL analysis of a system can be accomplished by a single analyst. A depth of knowledge of the operation of the system is the most valuable asset for the analyst. No formal training in the measurement or analysis of workload or in computer operations is assumed or required, although either would be valuable. The duration of

the project that analyzes a reasonably complex system will probably be measured in months rather than in days.

Purpose of the User's Guide

As noted, the goal of the user's guide is to instruct the user on all steps necessary to produce an operational workload prediction model. This requires that the user be instructed on how to perform a TAWL analysis on the system of interest and how to use the data obtained during the TAWL analysis to implement the model using the TOSS software. Until the release of the user's guide for Version 3.0 of the software (Bierbaum, Fulford, & Hamilton, 1990), little documentation existed describing the methodology divorced from its applications. The literature describing the application of the TAWL method did so with emphasis on the system being analyzed. This user's guide should be the only document necessary to use the TAWL methodology and Version 4.0 of the TOSS software; however, the reports listed below provide excellent examples of the application of TAWL.

Overview of the User's Guide

Research has demonstrated that the most effective documentation of computer software includes a global overview and detailed, step-by-step instructions (Holt, Boehm-Davis, & Schultz, 1989). Accordingly, Part I of the user's guide presents a global overview of the TAWL methodology and Part II presents step-by-step instructions on the use of Version 4.0 of the TOSS software. Part I fully describes the requirements and output of the methodology and should be read thoroughly prior to the initiation of the use of the TAWL methodology. The research tasks described in Part I require the majority of the project time.

The Overview and System Requirements sections at the beginning of Part II and the headings in all other sections of Part II should be read prior to project initiation. This will familiarize the user with the overall structure and function of the TOSS software. The step-by-step instructions should be referred to only when performing the tasks they describe.

Background

Anacapa Sciences, Inc., under contract to the U.S. Army Research Institute for the Behavioral and Social Sciences, has developed a methodology for predicting operator workload using the information produced from a task analysis of the system. The methodology originally was developed during the concept exploration and definition phase of the system development process for the Army's Light Helicopter Family (LHX) aircraft (Aldrich, Craddock, & McCracken, 1984; McCracken & Aldrich, 1984). Analyses were conducted to compare the operator workload of one- and two-crewmember configurations of the LHX. Subsequently, the methodology was refined for use in predicting the effect on operator workload of prospective modifications to existing Army helicopters. The refined methodology has been used to predict the

crewmember workload for existing and modified versions of the AH-64 aircraft (Szabo & Bierbaum, 1986), UH-60A aircraft (Bierbaum, Szabo, & Aldrich, 1989; Bierbaum & Hamilton, 1990a), and CH-47D aircraft (Bierbaum & Aldrich, 1990; Bierbaum & Hamilton, 1990b). The refined version of the methodology is called the Task Analysis/ Workload methodology. In addition, computer support for the methodology has been developed and named the TAWL Operator Simulation System (TOSS). An earlier version of the software is described in Bierbaum, Fulford, and Hamilton (1990). Initial validation of the TAWL methodology is described in a report by Iavecchia, Linton, Bittner, and Byers (1989). For a brief description of the methodology and software, see Hamilton and Bierbaum (1990) and Fulford, Hamilton, and Bierbaum (1990).

Overview

A TAWL workload prediction model is developed in the three stages portrayed in Figure 1. In the first stage, the analyst performs a task/ workload analysis on the system. A prototype mission for the system is identified and then is decomposed progressively into phases, segments, functions, and tasks. The analysis yields a description of the duration and sequence of each task and identifies the crewmember and subsystem associated with each task. The workload analysis is based on a multiple resources theory of human attention and yields independent estimates of the cognitive, psychomotor, and sensory components of workload (hereafter referred to as workload components) for each task. The theory differs from other multiple resource theories of attention in the nature and number of components identified. See Wickens (1984) for a review of other multiple resource theories of attention and their relation to workload.

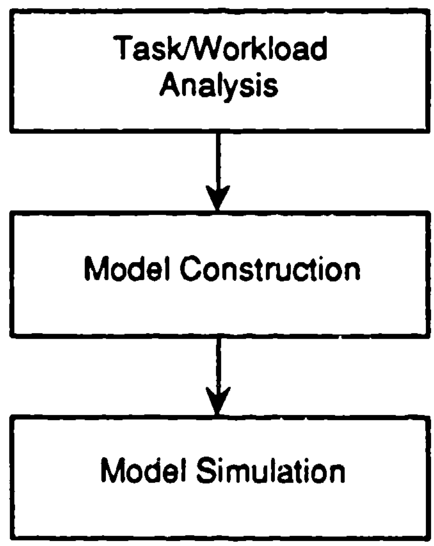

Figure 1. The three stages of a TAWL analysis.

The methodology treats each of the components independently for two reasons. First, although interactions between workload components probably occur, adequate definitions of the nature of the interactions do not exist. However, the developer may wish to test different models of the interactions with further processing of output from the TAWL methodology. Second, information that results from analyzing workload components individually is useful for determining appropriate ways to reduce or redistribute workload among the crewmembers, subsystems, or components. For example, a design engineer could decide whether additional information should be presented visually or aurally by determining which component had the least amount of workload.

The workload analysis is based upon subjective estimates of operator workload rather than estimates derived through experimentation. Analysts and subject matter experts (SMEs) generate workload estimates by using equal-interval, verbally anchored rating scales; the scale values range from 1.0 to 7.0. This approach avoids the expense in time, money, and manpower expected to derive empirical measures of workload.

In the second stage of the TAWL methodology, the analyst develops a model of each crewmember's actions and interactions by analyzing the sequence of tasks and functions during each segment of the mission. Function decision rules are developed that describe the sequencing of tasks in functions; segment decision rules are developed that describe the sequencing of functions in segments. It is assumed that the segments can be combined to model the mission phases and the entire mission.

In the third and final stage of the TAWL methodology, the crewmembers' actions are simulated during the operation of the system. The TAWL Operator Simulation System (TOSS) computer software performs the simulation and produces estimates of each crewmember's cognitive, psychomotor, and sensory workload for each half-second of the mission. The estimates of component workload are generated by summing the workload for that component across all tasks that the crewmember performs during each half-second of the mission. An overload threshold is used during execution to produce estimates of the amount of time during the mission that each crewmember is in an overload condition.

Using the TAWL prediction methodology, an analyst can develop a model of a system and use the model's output to determine:

- the absolute and relative workload of the crewmember at half-second time intervals,
- the time during which crewmembers experience high workload, and
- the components for which crewmembers experience high workload.

The information yielded by the TAWL methodology may enable system designers to reduce workload or to redistribute workload over time, crewmembers, or components. Designers also may use the information to identify design alternatives that result in lower workload.

In addition to the utility described above, models generated using the methodology produce mission timelines and task listings at half-second intervals that can be used to develop the systems' manning and training requirements.

The methodology is especially useful in the analysis of systems that require the concurrent or random execution of tasks. The predictions for concurrent task performance are obtained by summing workload estimates for each of the tasks being performed. Little insight will be gained in the analysis of systems whose operations are characterized simply by sequential task performance.

The methodology's multidimensional view of human capabilities allows the design engineer to identify modifications that shift operator workload from one

component to another. For example, technology designed to reduce an operator's need to maintain physical control of system functions often increases the operator's role as a monitor. Thus, advanced technology may decrease operators' psychomotor workload and increase their cognitive workload. Given the limited capacity of human cognitive ability, system designers must avoid shifting all the workload associated with system operations into the cognitive component (or any other single component, for that matter). Thus, this methodology, with its second-by-second estimate of operator workload, allows the design engineer to more readily utilize all of the operators' capabilities and, in turn, to increase system effectiveness.

The three stages of the TAWL methodology are discussed in more detail in the following sections. Examples are taken from an aviation context, but the methodology can be applied to other systems.

Task/Workload Analysis

The first stage of the TAWL methodology consists of two steps. To simulate the man-machine interface, the system's operation must be characterized. Thus, the first step is a top-down analysis of the system to decompose the system operation into operator tasks. A schematic representation of the task analysis is provided on the left side of Figure 2.

The second step is a workload analysis. Although the task analysis identifies the tasks required to operate a system, it does not provide sufficient information to predict the workload that the crewmembers experience. To assess the workload imposed by a system, some characterization must be made of the attentional demands that the tasks place on the operators. The sections that follow describe the task/ workload analysis in greater detail.

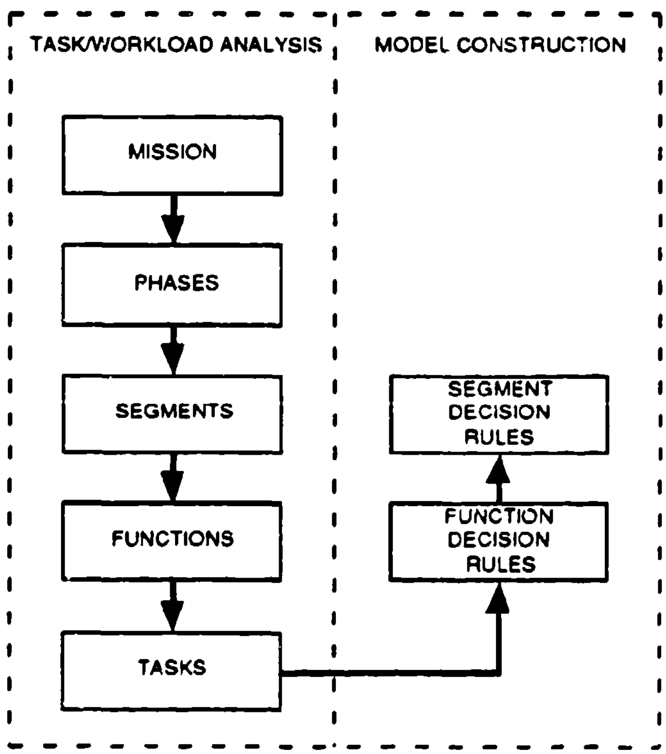

Figure 2. Task/workload analysis and model construction stages.

Task Analysis

The task analysis is a top-down decomposition of the overall operation of the system. The steps of the task analysis are listed below and discussed in the pages that follow:

- develop a composite mission scenario,
- divide the composite mission scenario into phases,

- identify the segments in each phase,
- identify the functions in each segment, and
- identify the tasks in each function.

At the highest level of analysis, each operation of the system, termed a mission, is designed to accomplish an objective. For example, an attack helicopter mission may consist of seeking out and destroying a group of enemy tanks. Because there are several ways to accomplish a mission, a composite mission can be developed from several unique mission profiles (e.g., different routes, different targets). The composite mission is a combination of the unique operations present in the various mission profiles.

After the mission is identified, the top-down analysis continues by dividing the mission into temporally discrete, uninterruptible, and nonrepeating divisions called phases. A phase is a required, logical part of a mission that may be accomplished in several ways. Phases must be sequential to other phases (i.e., they do not occur concurrently) and must be contiguous. All portions of the mission are encompassed under one of the mission phases and every phase must be performed to accomplish the mission. Thus, the mission is composed of a sequence of phases placed end to end. Mission phases identified for the attack helicopter include: preflight, departure, en route, target servicing, rearming, return, and postflight.

The mission phases are then divided into temporally discrete, uninterruptible parts called segments. A segment represents a particular method of accomplishing a part of a phase. Segments must be sequential to other segments and must be contiguous. Several segments may represent a variety of methods used to complete a portion of the phase; thus, every segment within the phase may not be needed to complete the phase. Segments may also be repeated in other phases. For example, the en route phase of the attack helicopter mission contains four segments: contour flight, nap-of-the-earth flight, approach, and landing. Thus, two versions of the en route phase are accomplished by sequentially performing three of the segments: contour flight, approach, and landing; or nap-of-the-earth flight, approach, and landing. Approach and landing are examples of segments that might also be found in other mission phases.

The next step is to identify all the interruptible parts of the segments, which are called functions. A function is defined as the collection of a crewmember's actions that are necessary to carry out a single logical activity. The same functions may be performed in different segments. Functions can be concurrent with or sequential to other functions in the segment. Examples of functions are: change battle position, hover masked, check instrument panel, and fire weapon. For each function identified during mission decomposition, a Function Analysis Worksheet is developed to organize the information gained from the analysis of the function. Table 1 presents an example of a Function Analysis Worksheet taken from the mission of the AH-64 helicopter. For ease of reproduction, blank copies of all the worksheets used in the methodology are presented in Appendix A, including a blank Function Analysis Worksheet.

Table 1

AH-64 Function Analysis Worksheet

FUNCTION 081 Load Weapons (Rearming) — TOTAL TIME (Approximate) 940 Seconds**

TASKS				WORKLOAD COMPONENTS				DURATION (SECONDS) DISCRETE/ CONTINUOUS	
VERB	OBJECT	ID #	SUBSYSTEM(S)	SENSORY	COGNITIVE	PSYCHOMOTOR	SWITCH DESCRIPTION		
Check	MASTER ARM Switch	P396	Weapons (AW)	Visually Inspect Switch Position and Check Light V-2(I)	Verify Current Position Correct (Safe/Light Illuminated) C-2		Toggle - 3 Positions (T-3)	1	
Set	TAILWHEEL Switch	P573	Gear (FG)	Visually Scan Switch Positions and Monitor Placement of Switch V-3(I)	Evaluate Position Options and Decide Correct Position (Locked) C-3	Move Switch P-1(L)	Safety Toggle - 2 Positions (ST-2)	1	
Set	Park Brake	P455	Brakes (FB)	Feel Brake Position K-2(F)	Decide and Verify Correct Positinn (Locked) C-3	Push Toe Brakes P-2(F)	Directional Foot Press (FP)	2	
Set	Brake Lever	P658	Brakes (FB)	Visually Locate Lever V-4(I)	Make Conditioned Association (Lever Set) C-1	Pull Handle P-2(R)	Push-Pull Handle (PPH)	1	
Check	Pylon Safety Pins	G481	Weapons (AW)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Pins Installed) C-2		Push-Pull Pin (PPP)	2	
Check	PLT/GND ORIDE Switch	G461	Electrical (UEL)	Visually Inspect Switch Position V-2(I)	Verify Current Position Correct (Off) C-2		Safety Toggle - 2 Positions (ST-2)	1	
Check	Grounding Cables	G283	Safety (S)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Installed) C-2			18	
Monitor	Weapons Loading	G641	Weapons (AW)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Loading Complete) C 2			3*	
Cont....	Continued...	Cont...	Continued...	Continued...	Continued...	Continued...	Continued...	Cont....	Cont....

*Represents a task that occurs randomly throughout the length of the function; the time reported for the task is the amount of time required to perform the task on each random occurrence.

**The reported time represents an estimate of the average amount of time required to land the aircraft; the actual time spent performing the task on a given occasion may be substantially higher or lower than the reported time.

The lowest level of mission decomposition is the task. Tasks are defined as the uninterruptible crew activities that are required for the successful completion of the function. Tasks can be concurrent with or sequential to other tasks in the function. Each task identified in a particular function is listed on the Function Analysis Worksheet for that function. Tasks are described by verbs and objects and are listed in the first two columns of the worksheet (see Table 1). The verb describes the crewmember's action and the object describes the recipient of the action. Examples of verbs include check, set, position, monitor, and release; examples of objects include switches, knobs, helmets, and maps.

For each unique task, three types of data must be determined. First, each crewmember who performs the task is identified in the analysis. A single letter (e.g., Pilot [P], Gunner [G], or Both [B]) in column 3 on the Function Analysis Worksheets indicates the crewmember(s) performing the task. Second, the subsystem equipment associated with the performance of each task is identified. For example, the task "Pull Laser Trigger" is associated with the Laser subsystem and the task "Set Park Brake" is associated with the Brakes subsystem. The subsystems associated with each task are logged on the Function Analysis Worksheet in column 4.

Finally, the time necessary to complete each task is estimated in two steps; each task is first categorized as discrete or continuous and then the duration is determined. Discrete tasks are defined as tasks whose magnitude or intensity of performance does not determine the magnitude of the resulting system change. Discrete tasks occur in open-loop control systems. For a complete review of the definition of open-loop and closed-loop control systems, see Wickens (1984). Activating switches and checking gauges are examples of discrete tasks. No matter how a switch is set (hard, fast, slow, soft), the system's response is the same. Estimates of the duration of discrete tasks are obtained from direct observation during system operation or simulation, or from SME interviews. The task duration is logged on the Function Analysis Worksheet in column 9 (columns 5-8 are reserved for the workload estimates).

Continuous tasks are tasks whose magnitude or intensity of performance determines the magnitude of the resulting system response. The resulting state of the system, in turn, determines the continuing magnitude or intensity of the operator's performance of the task. Continuous tasks, therefore, occur in closed-loop control systems. The task of controlling the pitch during contour flight in a helicopter is an example of a continuous task. The pertinent aspect of the system that changes when the pilot pushes forward on the cyclic (stick) is that the aircraft dives toward the ground. If the pilot pushes forward rapidly on the cyclic (high intensity or magnitude), the aircraft dives rapidly (system change). Often mission requirements determine continuous task durations. During a mission, the distance that the pilot is required to fly determines the duration of the task of controlling the aircraft's pitch. Continuous tasks are indicated on the Function Analysis Worksheets either by placing the letter "c" or the mission-determined duration in column 10.

Identification of the mission, phases, segments, tasks, crewmembers, subsystems, and durations completes the task analysis. The task analysis is performed with support from a number of sources. Task and duration information for existing systems can be obtained from observation of the operation of the system or a system

simulation. SMEs, such as operators of existing systems or development engineers of emerging systems, can provide the information necessary to perform the task analysis for systems under development. In addition, useful information may be obtained from checklists, specifications, training and tactics manuals, and other documents that describe the proposed or actual use of the system.

The TOSS software supports the task analysis by providing data base management of the information produced during the decomposition of the mission. TOSS maintains lists of segment names, function names, task names, crewmember names, and subsystem names, as well as a list of the subsystems associated with each task. The subsystems are categorized into major subsystem groups. Thus, the Laser subsystem is in the armament subsystem group, along with the fire control computer, gun control, rocket control, and missile control subsystems. The task analysis data can be created, updated, and printed using the TOSS software.

Workload Analysis

Knowing what tasks are necessary to operate a system does not provide sufficient information to predict the workload that the crewmembers experience while operating the system. To assess the workload imposed by a system, some characterization must also be made of the workload that the tasks place on the operators. The steps of the workload analysis are discussed below:

- determine the workload components pertinent to the application,
- develop or adopt workload component rating scales,
- write descriptions of the demands placed on the operators by the tasks, and
- compare the descriptions of the task demands with the workload rating scales to produce estimates for each workload component for each task.

Workload, as the term is used in this research, is defined as the total attentional demand placed on the operators as they perform the mission tasks. Consistent with Wickens' theory of human information processing, human attention is viewed as a multidimensional construct of limited availability (Wickens, 1984). This research methodology recognizes different components of attention (e.g., cognitive, psychomotor, and sensory). Thus, workload is the demand on each of these components imposed by all the tasks an operator is currently performing. The methodology further assumes that each of these components is a limited resource that, when expended, will result in degraded task performance or task shedding. The TOSS software can model up to six workload components. The exact decomposition of the components of workload is flexible in the program. For instance, TOSS can be used to model a theory of attention that identifies only two components, such as verbal attention and spatial attention.

Szabo and Bierbaum (1986) identified five workload components in the analysis of the AH-64 helicopter: cognitive, psychomotor, visual, auditory, and kinesthetic. The cognitive component referred to the attentional demand of information processing that the task required. The psychomotor component referred to the attentional demand required to make coordinated physical responses. The three sensory components

referred to the attentional demand of the task-relevant visual, auditory, and kinesthetic processing. Later, Bierbaum and Aldrich (1990) identified one additional component that was relevant to the analysis of the UH-60 helicopter. They identified two visual components: visual-unaided and visual-aided. The visual-aided component was used to describe the attentional demand of the visual processing using night vision goggles (NVG).

The workload analysis requires a workload rating scale for each workload component. The rating scales are used to assign a quantitative value to the amount of attentional demand in each component for each task. The scales should be comprehensive so that the full range of attentional demand is represented. At a minimum, the scales should establish a rank order among the levels of attentional demand; if possible, data should be collected to produce equal-interval scales. Examples of ordinal and interval cognitive workload rating scales are provided in Table 2. Appendix B contains a complete set of interval workload scales taken from a report by Bierbaum and Aldrich (1990). Ordinal scales can be found in a report by Szabo and Bierbaum (1986).

Table 2

Ordinal and Interval Cognitive Workload Rating Scales

Scale Value	Cognitive Anchors
	Ordinal
1	Automatic (Simple Association)
2	Sign/Signal Recognition
3	Alternative Selection
4	Encoding/Decoding, Recall
5	Evaluation/Judgment (Consider Single Aspect)
6	Evaluation/Judgment (Consider Several Aspects)
7	Estimation, Calculation, Conversion
	Interval
1.0	Automatic (Simple Association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (Consider Single Aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (Consider Several Aspects)
7.0	Estimation, Calculation, Conversion

Workload rating scales are developed by constructing verbal anchors that represent different levels of workload for each of the workload components. In the case of ordinal scales, the verbal anchors are ordered by the analysts to represent increasing workload and are assigned a corresponding number from 1 to the number of verbal anchors (see top of Table 2). Interval scales can be constructed using any number of psychometric scaling methods such as pair comparison or magnitude estimation (e.g., Engen, 1971).

Bierbaum and Aldrich (1990) used a pair comparison survey methodology to develop the set of scales shown in Appendix B. Using this method, UH-60 instructor pilots were presented with all possible pairs of the verbal anchors. For each pair, they were required to indicate the verbal anchor with higher workload. These data were used to weight and order the verbal anchors on an equal-interval scale. Refer to the bottom of Table 2 for an example of an interval workload rating scale.

The numerical estimates of workload for the individual tasks are generated using the rating scales. First, descriptions of the attentional demand of each task are written for each workload component. Often the performance of observable tasks requires several components. For example, consider the task of setting a switch in the cockpit. First, cognitive attention is required to decide that a new switch position is necessary. Next, psychomotor attention is expended to move the switch. Finally, visual attention may be required to ensure that the switch is placed in the correct position. Examples of these descriptions can be found in columns 5, 6, and 7 of the Function Analysis Worksheet shown in Table 1. Second, the verbal descriptions of the attentional demand are compared with the verbal anchors defining the rating scales. The purpose of comparing the verbal descriptions with the verbal anchors is to identify the verbal anchor that best represents the verbal description. The rating scale value associated with the best verbal anchor is assigned to represent the level of workload for that particular component of the task. These ratings are placed below the descriptions in columns 5, 6, and 7 of the Function Analysis Worksheet. Although one analyst may determine the workload rating, it is preferred that at least two analysts discuss the matches and reach a consensus on the rating for each workload component of each task. Subsequently, SMEs can review the consensual ratings.

The methodology allows for further categorization of the workload in each component. For example, psychomotor workload can be categorized by the portion of the body used to perform the task (e.g., left hand, right hand). In a similar manner, visual workload can be categorized by the location of the visual information being processed (e.g., internal or external to the cockpit). The TOSS software retains these categories as workload component specifiers and allows the analyst to define the specifiers that conflict with one another (e.g., two tasks that require the use of the left hand). TOSS uses this information during model execution to indicate that component specifier conflicts have occurred.

The workload analysis produces information describing the workload imposed by each of the tasks identified during the task analysis. TOSS provides data base management of the information gained during the workload analysis. TOSS maintains lists of the workload components used in the model and a list of the workload and

workload component specifiers associated with each component of each task. These lists can be created, updated, and printed using the software.

Prior to the full simulation of the operators' actions during the mission, the information about when the tasks will be performed needs to be developed. The process that the TAWL methodology uses to specify the scheduling of tasks during mission simulation is described in the section that follows.

Model Construction

The second stage of the TAWL methodology is the model construction. After the mission is decomposed to identify the tasks associated with the performance of the mission and estimates are made of the workload associated with each task, rules are developed to specify how the tasks are synthesized during the simulation to form functions and segments. Thus, the analyst must describe how the tasks are combined to form functions and how functions are combined to form segments during the model construction stage.

Function Decision Rules

Function decision rules specify the scheduling of tasks within a function. The function decision rules are developed in a two-step process. First, Function Summary Worksheets are developed. Second, function decision rules are developed using the Function Summary Worksheets.

For each of the unique functions identified during the decomposition process, a Function Summary Worksheet is developed. An example of a Function Summary Worksheet is shown in Table 3. The Function Summary Worksheet describes three types of information. First, the crewmember performing each task is indicated by placing the task name and number in a column under the appropriate crewmember's title. Second, the approximate temporal relationships among the tasks are portrayed by the position of the tasks on the worksheet: tasks placed higher on the page occur prior to tasks placed lower on the page; concurrent tasks are placed side by side. Third, the task category is indicated by placing it into one of the four columns below each crewmember's title.

For the purposes of the TAWL methodology, tasks are categorized using two dimensions: Discrete vs Continuous and Fixed vs Random. The Discrete vs Continuous distinction was described previously. The Fixed vs Random dimension relates to the time at which the task is performed during the mission. Fixed tasks are tasks that are performed at a predetermined time; that is, the performance of the task is fixed in relation to other tasks performed during the mission. Random tasks are tasks for which the time of performance is difficult or impossible to determine *a priori*. The performance of these tasks holds no fixed relation to other tasks during the mission, and the time at which random tasks are performed may be affected by any number of factors (e.g., individual differences, current workload).

Table 3

Function Summary Worksheet

FUNCTION 081 Load Weapons (Rearming)

PILOT				GUNNER			
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM
Check MASTER ARM Switch (396)				Set PLT/GND ORIDE Switch (461)			
Set TAILWHEEL Switch (573)							
Set Park Brake (455)							
Set Brake Lever (658)				Check Pylon Safety Pins (481)			
				Check Grounding Cables (283)			
					Monitor Weapons Loading (641)		
				Check Grounding Cables (283)			
				Check Pylon Safety Pins (481)			

When all four possible combinations of the two task dimensions are combined, the following definitions are produced:

- Discrete Fixed - A task that is performed at a predetermined time in the function and whose magnitude of performance does not determine the magnitude of the resulting system change (e.g., setting the park brake).
- Discrete Random - A task that is performed at an undetermined time in the function and whose magnitude of performance does not determine the magnitude of the resulting system change (e.g., check flight instruments, check obstacle clearance).
- Continuous Fixed - A task that is performed at a predetermined time in the function and whose magnitude of performance determines the magnitude of the system response; the resulting state of the system in turn, determines the magnitude of the subsequent performance of the task (e.g., perform visual search, track target).
- Continuous Random - A task that is performed at an undetermined time in the function and whose magnitude of performance determines the magnitude of the system response; the resulting state of the system, in turn, determines the magnitude of the subsequent performance of the task (e.g., control altitude, control drift, control attitude, control heading).

The Function Decision Rules Worksheets are developed using the Function Summary Worksheets. An example of a Function Decision Rules Worksheet is shown in Table 4. Function Decision Rules Worksheets specify the exact sequence and time for the performance of the tasks during the function. The decision rules on the worksheets specify the start time, duration, and crewmember performing each of the discrete fixed and continuous fixed tasks. For the discrete random tasks, the decision rules also specify the start and duration of the period during the function that a task may occur and the number of times that a task is expected to be performed. TOSS models the continuous random tasks as a set; the decision rules identify each task in the set, establish the duration of the tasks, designate the crewmember performing the tasks, and specify the start and duration of the period during the function that the tasks occur.

The TOSS software provides data base management of the function decision rules developed during the construction of the model. It maintains lists of the scheduling information for all four types of tasks that occur in function decision rules. The lists can be created, updated, and printed using the software. The Function Decision Rules Worksheets are then used in the development of the segment decision rules.

Table 4

Function Decision Rules Worksheet

FUNCTION 081 Load Weapons (Rearming)

PILOT				GUNNER			
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM
Program in sequence, the following tasks (include a .5-second delay between tasks): Task 396 for 1 second Task 573 for 1 second Task 455 for 2 seconds Task 658 for 1 second Standby 942.5 seconds				Program Task 461 for 1 second Standby 5.5 seconds When Task 658 ends, program, in sequence, the following tasks (include a .5-second delay between tasks): Task 283 for 18 seconds Continued...	Continued...		

Segment Decision Rules

After the function decision rules are completed, the segment decision rules are developed. Segment decision rules specify the scheduling of functions within a segment. The segment decision rules are developed in a two-step process. First, Segment Summary Worksheets are completed. Second, segment decision rules are developed using the Segment Summary Worksheets.

A Segment Summary Worksheet is developed for each unique segment identified during the decomposition process. An example Segment Summary Worksheet is shown in Table 5. The Segment Summary Worksheet describes three types of information. First, the crewmember performing each function is indicated by placing the name of the function in a column under the crewmember's title. If more than one crewmember performs tasks in the function, the name of the function is entered for each crewmember performing tasks in the function. Second, the approximate temporal relationships among the functions are portrayed by the position of the functions on the worksheet: functions placed higher on the page occur prior to functions placed lower on the page; concurrent functions are placed side by side. Third, the function category is indicated by placing it into one of the three columns below each crewmember's title. The methodology recognizes the following three categories of functions:

- Discrete Fixed - A function that is performed at a predetermined time in the segment and whose start and end points are defined by its discrete fixed tasks (e.g., mask aircraft, acquire target).
- Discrete Random - A function that is performed at an undetermined time in the segment and whose start and end points are defined by its discrete fixed tasks (e.g., monitor threat, cockpit communications).
- Continuous Fixed - A function that is performed at a predetermined time in the segment and whose start and end points are defined by its continuous fixed tasks. Thus, mission requirements and conditions determine their start and end points (e.g., hover unmasked, perform navigation).

The Segment Decision Rules Worksheets are developed using the Segment Summary Worksheets. An example of a Segment Decision Rules Worksheet is shown in Table 6. Segment Decision Rules Worksheets specify the exact sequence and time for the performance of the functions during the segment. The worksheets specify the start time and duration for each of the discrete fixed and continuous fixed functions. During the execution of a segment, an operator may halt the performance of one function, perform another function to completion, then continue to perform the first function from the point of interruption. This process is referred to as an interrupt. The segment decision rules identify the functions that interrupt each of the discrete fixed and continuous fixed functions.

Table 5

Segment Summary Worksheet

PHASE 4 Target Servicing

SEGMENT 44 Engagement, Gun (Gunner, Normal)

PILOT			GUNNER		
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED
	Monitor Threat (084)	Hover Unmasked (076)			Track Target (IHADSS/ Gunner) (150)
		Monitor Audio (083)	Fire Weapon, Gun (Gunner) (063)		Monitor Audio (083)
Mask Aircraft (082)	Initiate Cockpit Communication (Pilot) (079)			Initiate Cockpit Communication (Gunner) (078)	
	Initiate Cockpit Communication (Gunner) (078)			Initiate Cockpit Communication (Pilot) (079)	

Table 6

Segment Decision Rules Worksheet

PHASE 4 Target Servicing SEGMENT 44 Engagement, Gun (Gunner, Normal)

PILOT			GUNNER		
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED
	2 times, randomly select Function 084 to interrupt Function 076 for 3.5 seconds.	Start Segment 44 with Function 076. Function 076 lasts until Function 063 ends.	Start Function 063 4.5 seconds after Function 150 begins. Function 063 lasts 9.5 seconds.		Start Segment 44 with Function 150. Function 150 lasts until Function 063 ends.
Start Function 082 when Function 076 ends. Function 082 lasts 7.5 seconds.	Randomly select (.50) Function 078 or 079 to occur concurrently with Function 082. Functions 078 and 079 last 7 seconds each.	Start Function 083 concurrently with Function 076. Function 083 lasts throughout the segment.		Randomly select (.50) Function 078 or 079 to occur concurrently with Function 082. Functions 078 and 079 last 7 seconds each.	Start Function 083 concurrently with Function 150. Function 083 lasts throughout the segment.

The Segment Decision Rules Worksheets specify a start and finish time that define the time window in which each of the discrete random functions occur. This active period can span the entire segment or only part of it. The worksheets also specify the number of times that each discrete random function is expected to occur during the active period. For example, the discrete function of checking engine instruments is performed randomly by the pilot approximately once every 180 seconds during contour flight. In a segment consisting of takeoff (300 seconds), contour flight (600 seconds), and landing (300 seconds), the active period for the random performance would start at 300 seconds and finish at 900 seconds into the segment, and the number of times that the function would be expected to be performed is 3. During takeoff and landing, the same function is modeled as a discrete function.

Finally, the Segment Decision Rules Worksheets specify the pairs of functions that may not be executed concurrently. These functions are referred to as function clash pairs. If two functions clash, the execution of the second function is delayed until the first function is finished. For example, a pilot cannot communicate with the copilot and the tower at the same time. Thus, the functions "perform cockpit communications" and "perform external communications" are a clash pair. Two functions that clash in any segment, clash in every segment; therefore, the function clash pairs are specified only once for the entire model.

The TOSS software provides data base management of the segment decision rules developed during the construction of the model. Lists of the scheduling information for all three types of functions that occur in segment decision rules are maintained by the system. It also maintains a list of function clash pairs. The lists can be created, updated, and printed using the software.

The development of the function and segment decision rules completes the construction of the model data base. The following section describes the simulation of a model developed using the TAWL methodology.

Model Simulation

The third stage in the TAWL methodology is the model simulation. The specification of segments, functions, tasks, function decision rules, segment decision rules, and function clash pairs enables TOSS to simulate the crewmember tasks during each segment of the mission. The following paragraphs describe the randomization, workload summation, and overload computation procedure used in the simulation. The results of model simulation are also discussed.

Randomization

During model construction, some of the tasks and functions are categorized as random. During model simulation, TOSS can randomize two different aspects of the random tasks and functions. First, the start times of the tasks and functions can be generated randomly. Second, the number of times that the tasks and functions are scheduled to occur can be random. When the number of times that the tasks and

functions is randomized, the number of times they are performed during simulation varies. They may not be performed at all or they may be performed as many as 1.5 times the expected frequency.

Workload Summation

TOSS estimates the crewmember workload imposed by concurrent tasks by summing the workload ratings for individual workload components. For example, during a specific half-second interval, the pilot performs the tasks: Control Attitude, Check External Scene, and Transmit Communication. The cognitive workload for the three tasks during that interval is 1.0, 1.0, and 5.3, respectively. Thus, the estimate of cognitive workload for the pilot during that interval is 7.3.

Version 4.0 of the TOSS software allows further calculation using the component workload estimates. The software can produce estimates of workload consisting of the addition, subtraction, multiplication, division, or exponentiation of any of the defined workload components or numerical constants. The ability of the software to generate general mathematical combinations of the workload components is useful. For example, using a regression equation, TOSS can be used to predict other workload scales (e.g., subjective workload measures) from TAWL component workload estimates (see Bierbaum & Hamilton, 1990a).

Overload Threshold

The TAWL methodology defines operator overload as the level of workload at which operator performance begins to degrade. Using TOSS, any workload level can be established as an overload threshold. In the model developed for the AH-64A attack helicopter analysis, the overload threshold was set at 8, because the verbal anchor representing the highest possible workload was assigned a magnitude of 7 on the workload rating scales. Therefore, workload that sums to 8 or more is considered to be an overload. The exact overload threshold has yet to be identified through experimentation.

The overload threshold is used to compute four metrics of overload for each execution of the model: component overloads, overload conditions, overload density, and subsystem overloads. Component overloads are the number of half-second periods that a workload component exceeds the overload threshold. Overload conditions are the number of variable-length periods when one or more component overloads occur. A new overload condition is counted whenever the tasks contributing to a component overload change. Overload density is the percentage of time that an overload condition occurs within a mission segment. Finally, subsystem overloads are the number of times that a subsystem is associated with a component overload.

Simulation Results

The segment level of analysis is the highest level directly simulated by TOSS. The software simulates one segment at a time. The methodology assumes that phases and missions can be adequately simulated by the sequential analysis of their constituent segments. The simulation of each segment of a workload prediction model produces timeline and summary information.

The following timeline information is generated for each crewmember in the model:

- a timeline of the segment annotated with the task and function names and the current time,
- estimates of component workload for each half-second of the segment,
- indication of component overloads,
- indication of the current total of overload conditions,
- indication of the subsystems associated with all the tasks being performed during each overload condition, and
- indication of periods in which concurrent tasks have conflicting workload specifiers.

The following summary information is generated for each crewmember in the model:

- the number of component overloads during the segment,
- the number of overload conditions and the overload density during the segment,
- the average, peak, and standard deviation of each workload component during the segment,
- the subsystem overloads during the segment,
- the amount of time each subsystem was utilized during the segment,
- the average workload associated with each subsystem by component,
- the subsystem impact (subsystem utilization time multiplied by average workload) by workload component,
- the number of times that the discrete random functions occurred during the segment, and
- the current setting of all model parameters (e.g., overload threshold, randomization).

Analysts or SMEs may review the results to determine if the decision rules produce a realistic simulation of the mission. Often, the original decision rules need to be revised to generate a more realistic simulation. The development of a workload prediction model is complete when the model produces a realistic simulation of all mission segments.

Summary

The TAWL methodology produces a model that predicts operator workload for new or existing systems. The method relies on a comprehensive task analysis of a system's typical mission to simulate each operator's actions. The workload analysis produces estimates, by component, of the attentional demands of each task.

The methodology uses decision rules to specify the sequence of events in the mission simulation. During simulation, the workload estimates for the tasks that the operator is currently performing are summed separately for each component. Thus, the methodology represents each operator's workload for each half-second of the mission, with a separate value for each of the workload components. The methodology identifies the component overloads, overload conditions, overload density, and the subsystems associated with overload.

Step-by-step instructions for using TOSS VERSION 4.0 in support of the TAWL methodology are provided in the second part of the User's Guide.

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Part II

TAWL Operator Simulation System (TOSS)

Version 4.0

OVERVIEW

The TOSS Version 4.0 software was developed to support the Task Analysis/Workload (TAWL) methodology. TOSS performs all of the data base management and model simulation functions needed to use the methodology. The task data and the decision rules are entered using the data entry routines of the software or are imported from standard format dBASE files. The conditions specified in the decision rules are implemented to build functions from tasks and segments from functions. When provided with this information, TOSS simulates the behavior of the crewmembers during the segment and identifies all tasks performed by each crewmember during each half-second of the segment. Totals are maintained for each workload component to identify the conditions and density of operator workload for each segment.

TOSS can be used to manage more than one workload prediction model. This allows for the comparison and analysis of several models at once. A user can create a data base (enter, update, and print data), simulate, or change models from within the software. The program is menu-driven with on-screen directions.

As well as being able to produce reports of the information that has been entered into a model, TOSS can produce the following five forms of output describing the results of the simulation of a mission segment:

- Screen Output,
- Simulation Listing Files,
- Abbreviated Simulation Listing Files,
- Numerical Data Files, and
- Task Listing Files.

The output options are selected from the Model Simulation routine. Each option is described in that section of this report, starting on page 67.

SYSTEM REQUIREMENTS

To use TOSS Version 4.0, the following hardware is either required or recommended:

- an IBM compatible computer and a keyboard (required),
- 640 Kb of memory (required),
- a hard disk drive (recommended), and
- a printer (recommended).

INSTALLING TOSS VERSION 4.0

To install TOSS Version 4.0 on your hard drive, perform the following steps:

1. Place the TOSS diskette #1 into a floppy drive.

2. Type "[drive]:INSTALL" where [drive] is the single letter name of the drive that contains the TOSS diskette and press the [ENTER] key (e.g., A:INSTALL).

   This command executes the INSTALL.EXE file. To execute the install program on a monochrome system, type "/M" on the same line as the INSTALL command. The program prompts for the drive containing the TOSS diskette. Type the letter of the drive and press the [ENTER] key. The program prompts for the destination drive. Type the letter of the destination drive (preferably a hard drive) and press the [ENTER] key. The installation procedure can be aborted at any time by pressing the [ESC] key. Follow the program instructions and insert the additional TOSS diskettes when prompted. The program creates a \TOSS subdirectory on the destination drive and copies all necessary files to that directory. To install TOSS on a subdirectory other than \TOSS, type the subdirectory name as a parameter to the INSTALL command (e.g., A:INSTALL MODEL).

   The program then prompts: **CONVERT VERSION 3 MODELS TO VERSION 4?** If you are a new TOSS user and don't have any models created under version 3.0 of the software, press the [N] key to end the installation procedure. If you do have TOSS version 3.0 models that you would like to update to run under version 4.0, press the [Y] key to execute the conversion program UPDATE.EXE and follow the instructions listed in Appendix C to convert the models.

   Installation of TOSS should be required only once.

GETTING STARTED

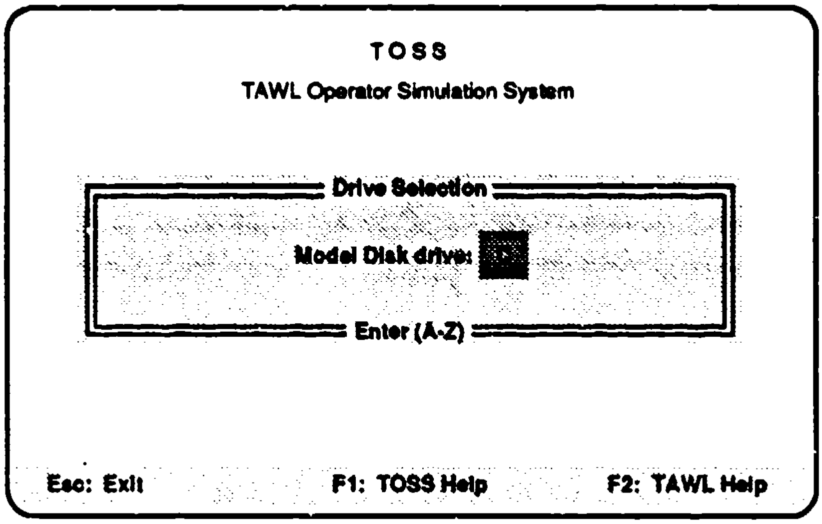
To use TOSS for the development of a workload prediction model, execute the following steps:

1. Type the DOS command "CD \TOSS" and press the [ENTER] key.

   This command changes the current directory to the TOSS subdirectory. To avoid issuing this command every time you run TOSS, place the TOSS subdirectory on the DOS path as specified in the DOS manual.

2. Type "TOSS" at the DOS command line (or "TOSS/m" if you are working on a monochrome system) and press the [ENTER] key. This command executes TOSS and presents a brief introductory screen with the display of a helicopter

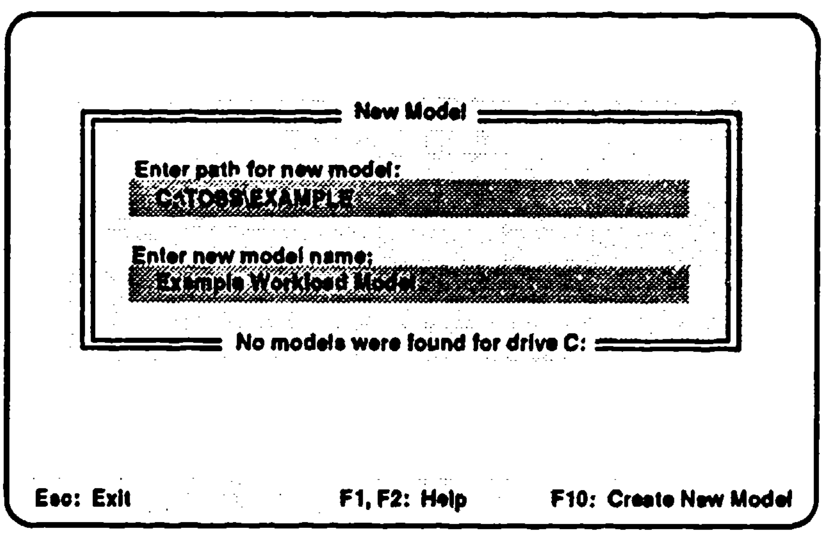
(TOSS was originally developed for rotary wing aircraft). The helicopter display is followed by the Drive Selection window.



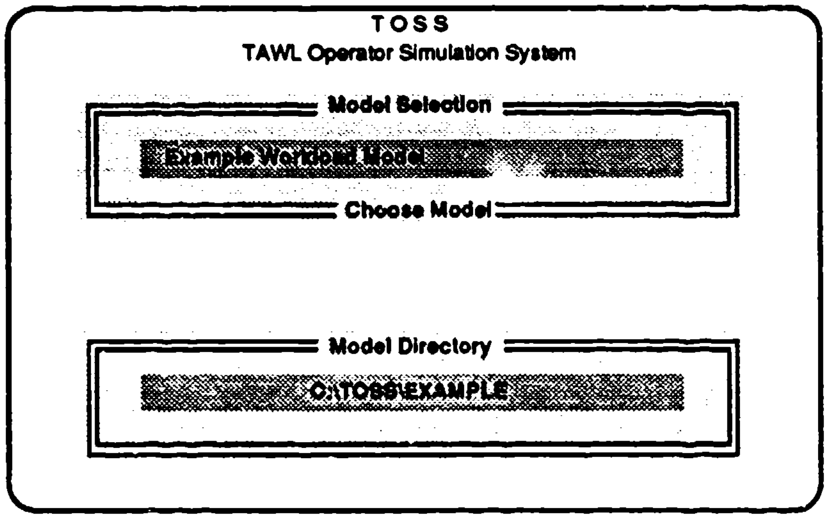
3. Enter the disk drive designation and press the [ENTER] key.

   TOSS maintains workload models as sets of data files. Normally the data files are kept on the same disk drive as the TOSS software, but you may specify any disk drive (A-Z). The software defaults to the current disk drive. If the data files are on the current drive, press the [ENTER] key. If the files are on a different drive, enter the letter for the drive and press the [ENTER] key.

   If there are no model data files on the disk, TOSS opens the New Model window.



To create a new model, enter the name of the new model's subdirectory and press the [ENTER] key. Enter the model name and press the [ENTER] key. Press the [F10] key to create the new model; press the [ESC] key to abandon the creation of the new model and return to the Drive Selection window. After pressing the [F10] key, the Model Selection window opens.



4. Select the desired model using the arrow keys and press the [ENTER] key.

   TOSS can work with many different workload models on the same computer system. The computer files that represent different models are maintained in separate disk subdirectories. If the model data files are already loaded on the computer, the model name will appear on the list of models. The subdirectory that contains the selected model will appear at the bottom of the screen. The display will scroll, if necessary.

   Models can be inserted, deleted, stored, and restored from the Model Selection window. For instructions in performing any of these procedures, see the Model Selection section of this report, beginning on page 86.

GENERAL INTERFACE INSTRUCTIONS

Knowing the principles of the TOSS user interface should prove useful in the manipulation of the software. Prior to proceeding with the full description of the use of the TOSS software, the general guidelines of the user interface are explained in the following two paragraphs.

Many of the windows in the software contain user selectable options. When a window is first displayed, one of the options is highlighted and other options can be designated using the [↑], [↓], [→], [←], [TAB], [SHIFT TAB], [PG UP], or [PG DNkeys. The highlighted option can be chosen by pressing the [ENTER] key. For windows containing numbered menus, the options can also be selected by pressing the corresponding number on the computer keyboard without moving the highlighted area. All windows in the software are terminated by pressing the [ESC] key.

There are two forms of context sensitive help available. For help concerning the operation of the TOSS software, press the [F1] key. For help concerning the TAWL methodology, press the [F2] key.

DEVELOPING THE MODEL

After a model is selected, the Main Menu is displayed.

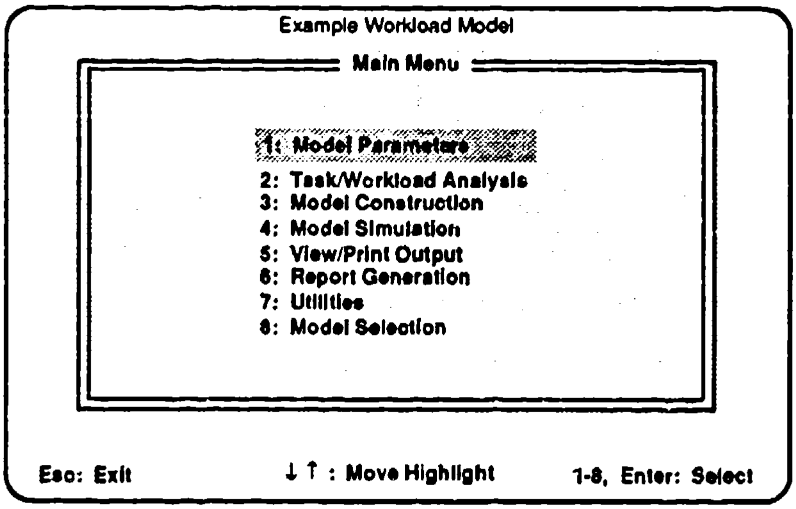


Table 7 presents a list of the Main Menu selections and the subordinate windows.

Table 7

Selections in Main Menu and Subordinate (Second Level) Windows

Main Menu (First Level)	Subordinate Windows (Second Level)
1. Model Parameters	Model Name Crew Configuration Workload Components Workload Equation Subsystem Groups Random Function and Task Modes
2. Task/Workload Analysis	Task Names Task Subsystems Task Workloads
3. Model Construction	Function Decision Rules Segment Decision Rules Function Clash Pairs
4. Model Simulation	Model Output Options/Segment Selection
5. View/Print Output	Select, View, Print, Search Files
6. Report Generation	Report Menu
7. Utilities	Import/Export Data Files Workload Conversion Customize Colors
8. Model Selection	Drive Selection/Model Selection Insert, Delete, Backup, Restore a Model

There are three levels of windows in the TOSS software. The use of all three window levels is described in the following sections of the user's guide. The description of each window is formatted differently to indicate its level. Figure 3 displays the different formats for the three levels.

1 MAIN MENU OPTIONS

The text that describes the Main Menu Options in the first level window has the widest margins and is in full block format.

SECOND LEVEL WINDOWS

The text that describes the second level windows has narrower margins.

THIRD LEVEL WINDOWS

The text that describes the third level windows has the narrowest margins.

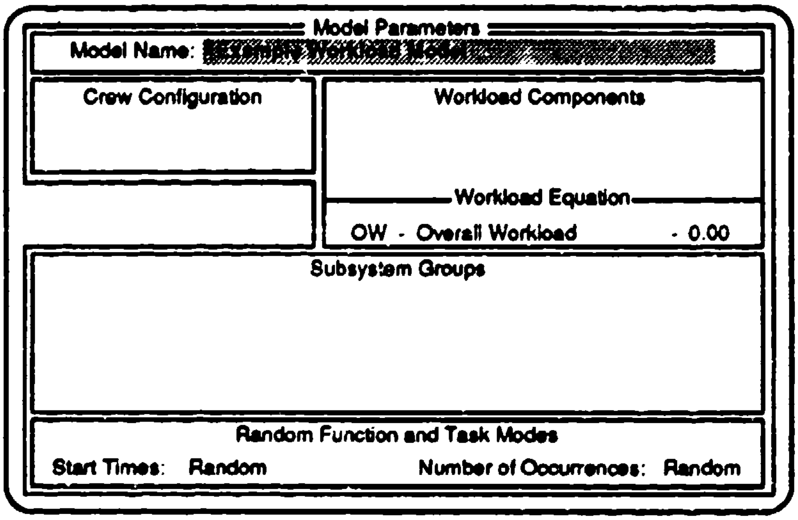
Figure 3. Text format for the descriptions of the three levels of windows in TOSS.

The first level window contains the Main Menu. The main menu options are described in the following major sections, each beginning with a rectangular shaped symbol and starting on a new page. The second level windows are indicated within the first level by sections beginning with a diamond shaped symbol. The third level windows are indicated within the second level by sections beginning with an oval shaped symbol. For options appearing in numbered menus, the number of the corresponding computer key appears inside the symbol.

1 Model Parameters

TOSS uses a number of parameters to define the basic characteristics of a workload prediction model. Those parameters are entered or modified in TOSS using the Model Parameters window.

Press the [1] key on the Main Menu to open the Model Parameters window.



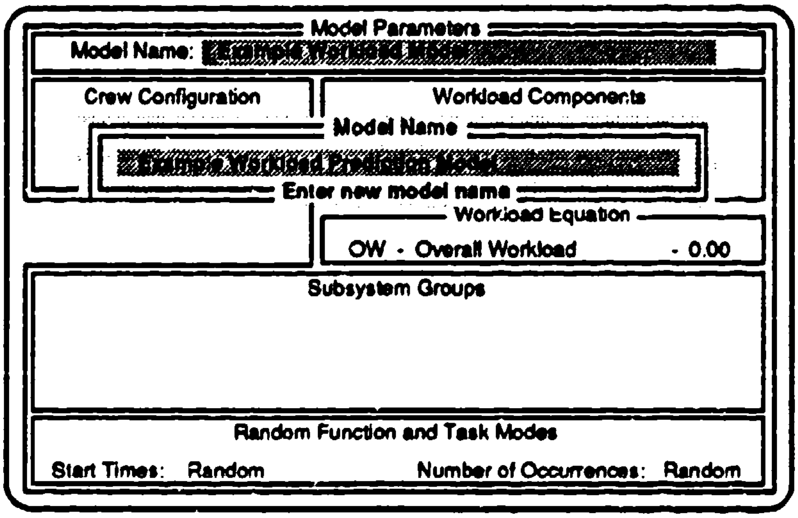
The Model Parameters window has six different areas or blocks:

- Model Name,
- Crew Configuration,
- Workload Components,
- Workload Equation,
- Subsystem Groups, and
- Random Function and Task Modes.

These blocks are fully described in individual sections beginning on the next page.

MODEL NAME

The Model Name block is highlighted where the present name for the model is displayed. To change the name of the model, press the [ENTER] key.



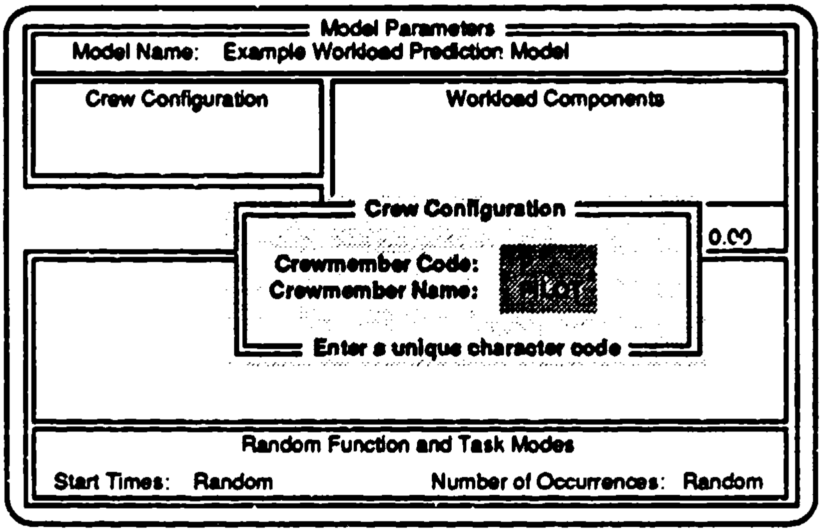
The Model Name window opens to allow a new model name to be entered. Enter the new name and press the [ESC] key to save the changes or press the [ESC] key to leave the model name unchanged.

The Model Name is used to identify the model during model selection and should be unique. It is used in the page headings for all model simulation output and reports.

CREW CONFIGURATION

Press the [→] or [TAB] key to move the highlighted area to the Crew Configuration block. Up to four crewmembers may be entered in a model.

To add a crewmember, press the [INSERT] key.



The Crew Configuration window opens. Press the single letter (A-Z) key to designate the crewmember code. Then press the [ENTER] key.

Type the crewmember's name (up to 8 alphanumeric characters, no spaces) and press the [ENTER] key. Press the [ESC] key to return to the Model Parameters window.

The new crewmember now appears in the Crew Configuration block. Continue this process until all crewmembers are entered.

To delete a crewmember, press the [↑] or [↓] key to highlight the crewmember and press the [DELETE] key.

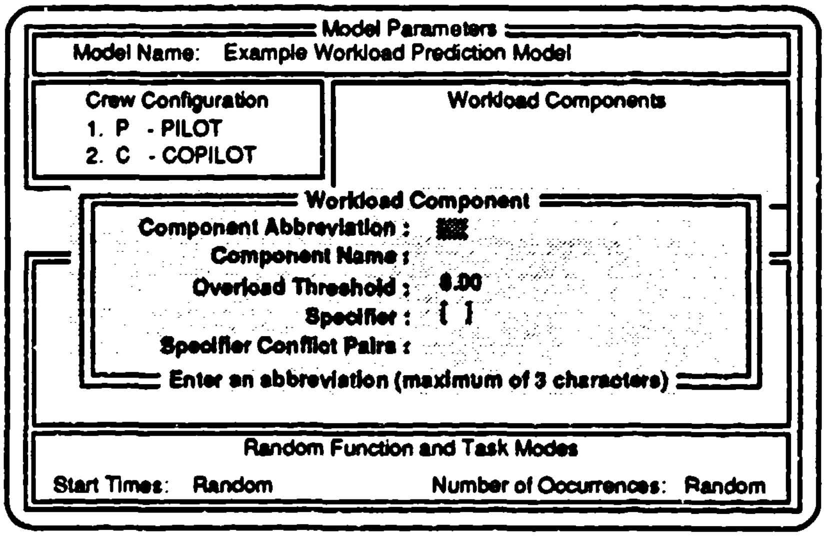
To change a crewmember entered previously, highlight the crewmember using the [↑] or [↓] key. Press the [ENTER] key and the Crew Configuration window will display the current data. To move within the window to change the data, press the [ENTER], [↑] or [↓] key. To change the crewmember code, type the new letter and press the [ENTER] key. To change the crewmember name, press the [DELETE] key to erase the present name and enter the new name. Then press the [ENTER] key.

Press the [ESC] key to return to the Model Parameters window.

WORKLOAD COMPONENTS

Press the [→] or [TAB] key to move the highlighted area to the Workload Components block. Up to six workload components may be entered in a model.

To add a workload component, press the [INSERT] key and an empty Workload Components window opens.



Type the component abbreviation (up to 3 letters) and press the [ENTER] key.

Type the component name (up to 12 alphanumeric characters) and press the [ENTER] key.

The default overload threshold is 8.0. To change the overload threshold, type the desired number and press the [ENTER] key or press the [ENTER] key to leave the overload threshold unchanged.

The cursor moves to the SPECIFIER prompt. If there are no specifiers for the component, press the [ESC] key to save the information, close the window, and return to the Model Parameters window.

WORKLOAD COMPONENTS (CONTINUED)

To add further categorization to the workload components, enter the single letter specifiers (e.g., an E and I for External and Internal visual components).

To delete a specifier entered in error, reenter the letter.

When all specifiers are entered, press the [ENTER] key. The cursor moves to the SPECIFIER CONFLICT PAIRS prompt and the following instructions are displayed: Ins: Append Del: Delete ← →: SELECT

To append a Specifier Conflict Pair, press the [INSERT] key and type the first specifier followed by the second specifier.

To delete a conflict pair, highlight the pair using the [←] or [→] key and press the [DELETE] key.

Continue this process until all the conflict pairs have been entered, then press the [ENTER] key. Press the [ESC] key to save the information, close the window, and return to the Model Parameters window.

The new workload component now appears in the Workload Components block. Continue the procedure until all the workload components are entered.

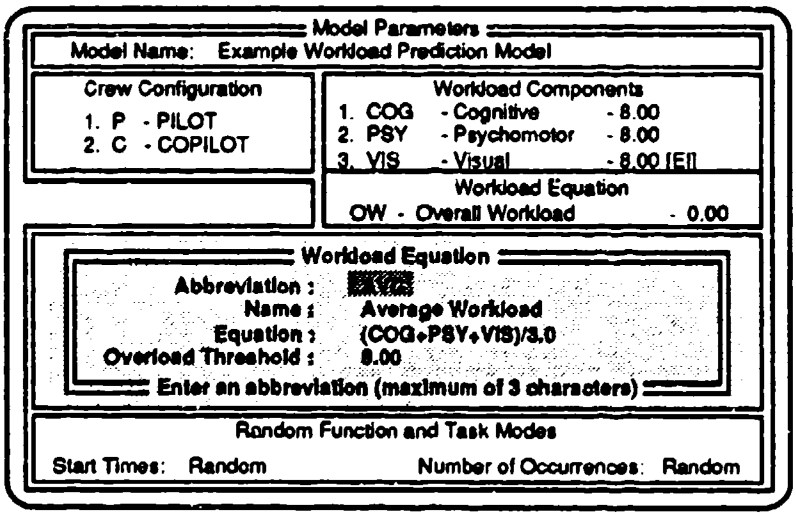
To delete a workload component and all its associated data, press the [↑] or [↓] key to highlight the workload component and press the [DELETE] key.

To edit a workload component already entered, press the [↑] or [↓] key to highlight the component. Press the [ENTER] key and the Workload Component window is displayed. Press the [ENTER], [↑] or [↓] key to highlight the data and follow the procedures described above to enter new information. Press the [ESC] key to save the changes and return to the Model Parameters window.

WORKLOAD EQUATION

Press the [→], [↓], or [TAB] key to move to the Workload Equation block. The workload equation can be used to combine workload components to generate another workload prediction. If no prediction of combined workload is required, this option can be ignored.

To insert a workload equation, press the [ENTER] key and the Workload Equation window opens.



Type the abbreviation (up to 3 letters) for the workload equation and press the [ENTER] key. Type the name (up to 12 alphanumeric characters) of the workload equation and press the [ENTER] key.

Enter the workload equation and press the [ENTER] key. The equation may contain reference to any of the previously defined workload components, numerical constants, parentheses, or any of the following mathematical operators: addition (+), subtraction (-), multiplication (*), division (/), or exponentiation (^). To reference a workload component, use the three letter abbreviation of the component in the equation. When editing the equation, the [INSERT] key toggles between insert mode and overwrite mode, the [DELETE] key deletes the character at the cursor, the [BACKSPACE] key deletes the character to the left of the cursor, the [HOME] key moves the cursor to the beginning of the equation, the [END] key moves the cursor to the end of the equation, and the [←] and [→] keys move the cursor left or right one space.

WORKLOAD EQUATION (CONTINUED)

When the equation is complete, press the [ENTER] key. If TOSS can interpret the equation, the highlighted area will move to the OVERLOAD THRESHOLD prompt. If TOSS cannot interpret the equation, the bell will sound, a diagnostic error message will be displayed, and the cursor will return to the workload equation. Correct the equation using the appropriate editing keys [INSERT], [DELETE], [BACKSPACE], [HOME], [END], [←], [→]. Then press the [ENTER] key.

Type the desired overload threshold and press the [ENTER] key or press the [ENTER] key to leave the overload threshold unchanged.

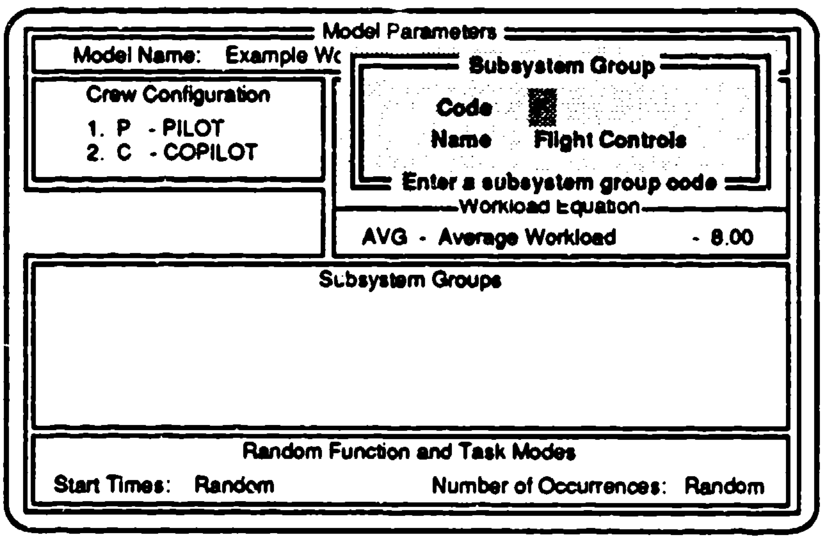
To edit any of the data already entered, press the [ENTER], [↑], or [↓] key to highlight the data and follow the procedures described above.

Press the [ESC] key to return to the Model Parameters window. The new workload equation will appear in the Workload Equation block.

SUBSYSTEM GROUPS

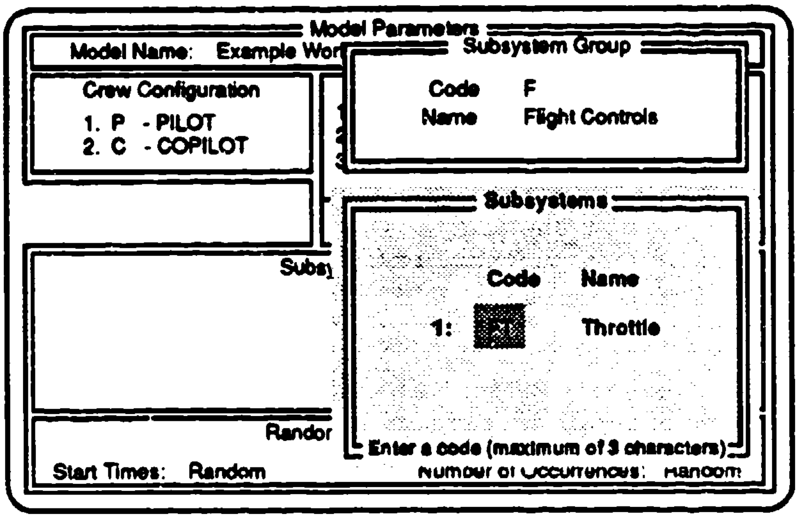
Press the [→] or [TAB] key to move the highlighted area to the Subsystem Groups block. Up to 7 subsystem groups with up to 10 subsystems in each subsystem group may be entered in the model.

To add a new group of subsystems, press the [INSERT] key and the Subsystem Group window opens.



Enter the single letter designator for the subsystem group, then press the [ENTER] key. Enter the name (up to 30 alphanumeric characters) and press the [ESC] key. The Subsystems window now opens.

SUBSYSTEM GROUPS (CONTINUED)



To add a new subsystem, press the [INSERT] key. Type a subsystem code (up to 3 letters) and press the [ENTER] key. Type the subsystem name (up to 30 alpha-numeric characters) and press the [ENTER] key.

Continue this process until all subsystem codes and names are entered for the subsystem group. Press the [ESC] key to return to the Model Parameters window.

The new subsystem group will now appear in the Subsystem Groups block. Continue this process until all subsystem groups and subsystems are entered.

To delete an entry to the list, press the [↑] or [↓] key to highlight the name of the desired subsystem group. To delete the complete subsystem group, press the [DELETE] key. To delete a subsystem of the group, press the [ENTER] key to display the Subsystem Group window, the [ESC] key to display the Subsystem window, and the [↓] key until the subsystem is highlighted. Then press the [DELETE] key. Press the [ESC] key to return to the Model Parameters window.

To edit an entry on the list, press the [↑] or [↓] key to highlight the subsystem group. Press the [ENTER] key to display the Subsystem Group window. Use the [ENTER] or [↓] key to highlight the field and type the correct data. Then press the [ENTER] key. Press the [ENTER] key to leave any entry unchanged. Press the [ESC] key to display the Subsystems window and use this same procedure to change subsystem information.

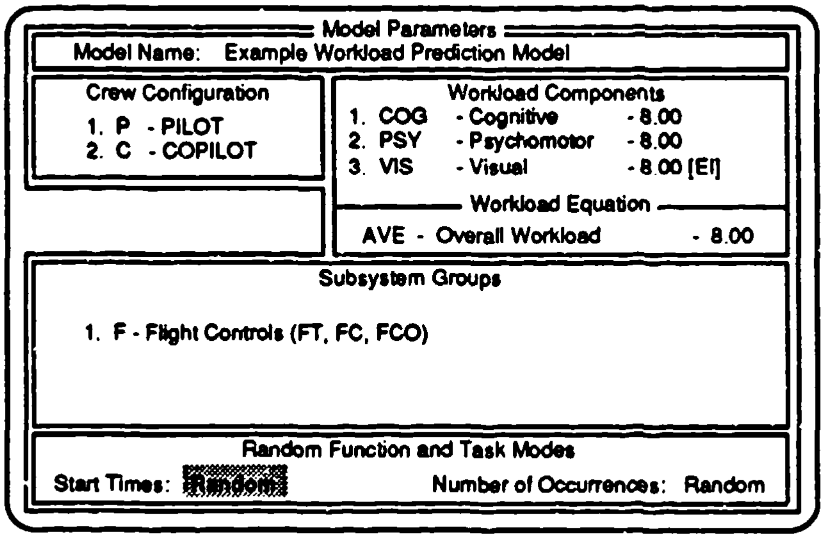
When all editing of subsystem data is complete, press the [ESC] key to return to the Model Parameters window.

RANDOM FUNCTION AND TASK MODES

Press the [→] or [TAB] key to move to the Random Function and Task Modes block.

TOSS simulates tasks and functions that are categorized as random in two ways. First, TOSS randomizes or fixes the start times for random functions and tasks. Second, it randomizes or fixes the number of times they occur. The default mode for both of these options is **RANDOM**.

To change the mode of the start times for random functions and tasks, highlight the start time option and press the [ENTER] key. When the start times option is **RANDOM**, a new set of start times is generated each time the model is executed. When the start time option is **FIXED**, the same random set of start times is used during each simulation.



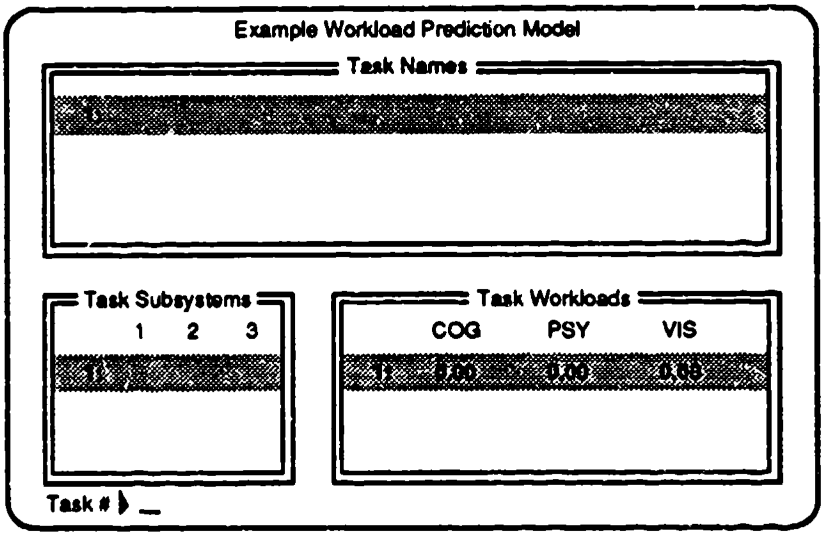
To change the mode of the number of occurrences of random functions and tasks, highlight the occurrences option and press the [ENTER] key. When the occurrences option is **RANDOM**, the number of times that the random functions and tasks occur varies from 0 to 1.5 times the number specified in the decision rules. When the occurrences option is **FIXED**, the number does not vary from the number in the decision rules. The occurrences option automatically changes to fixed when the Start Time option is **FIXED**.

Setting the random function and task modes completes the specification of the model parameters. The [←], or [→], [TAB], or [SHIFT TAB] keys can be used to highlight different parts of the Model Parameters window if additional changes are required. Press the [ESC] key to return to the Main Menu. The prompt **SAVE CHANGES TO MODEL PARAMETERS?** is displayed. To save the changes, press the [Y] key, followed by the [ENTER] key. To erase the changes, press the [N] key, followed by the [ENTER] key.

2 TASK/WORKLOAD ANALYSIS

After the mission task analysis is complete, use the Task/Workload Analysis routine to enter the task data obtained from the analysis.

Press the [2] key on the Main Menu to open the Task/Workload Analysis window.



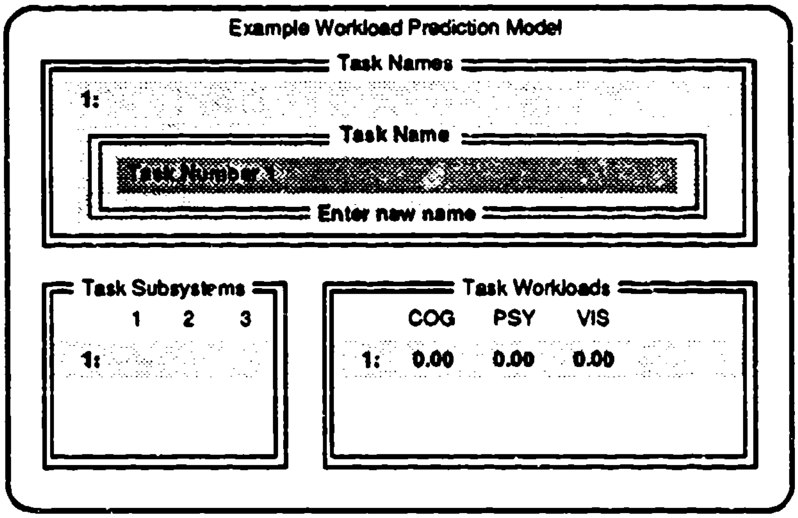
The Task/Workload Analysis routine has three different windows:

- Task Names,
- Task Subsystems, and
- Task Workloads.

These windows are fully described in individual sections beginning on the next page.

TASK NAMES

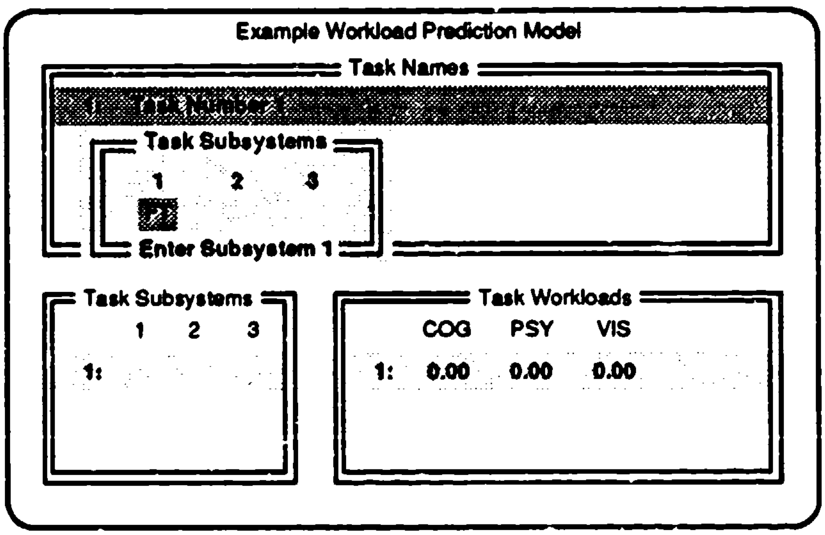
Press the [ENTER] key to enter the name of the first task in the model. The Task Name window opens with a prompt for the task name.



Enter the task name (up to 66 alphanumeric characters) and press the [ESC] key to save the name and open the Task Subsystems window.

TASK SUBSYSTEMS

The subsystems the crewmember uses to accomplish a task are entered in the Task Subsystem window.



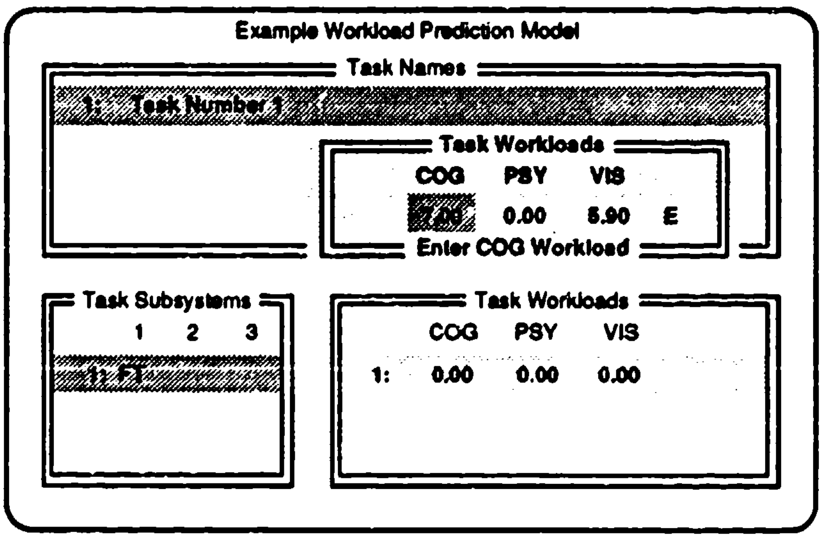
Space is available for up to three subsystem codes for each task. Enter each subsystem code associated with the task and press the [ENTER] key.

The subsystem code entered must be listed in the Model Parameters subsystem list or the program displays the message "??? **IS NOT A SUBSYSTEM CODE.**"

Press the [ESC] key when all the task subsystems are entered to open the Task Workloads window.

TASK WORKLOADS

Workload ratings can be entered for each of the components previously defined in the Workload Components window of the Model Parameters. If the equal-interval scales shown in Appendix B are being used, pressing the TAWL HELP key [F2] will display the scale of the workload component being entered.



For workload components that do not have specifiers, enter the workload rating for the highlighted component and press the [ENTER] key to move to the next component.

For workload components that do have specifiers, enter the workload rating for the highlighted component and press the [ENTER] key to move to the specifier field. TOSS displays the currently defined specifiers for that component at the bottom of the window. Enter the single letter specifier and press the [ENTER] key to move to the next component.

If no workload is associated with a component, press the [ENTER] key to move to the next component.

TASK WORKLOADS (CONTINUED)

Continue entering the workload ratings for all components of the task. Press the [ESC] key to return to the Task/Workload Analysis window. The **SAVE THE CHANGES TO TASK #1?** prompt is displayed. Press the [Y] key, followed by the [ENTER] key, to save the data entered. Press the [N] key, followed by the [ENTER] key, to erase the data entered.

To add tasks, press the [INSERT] key and follow the procedures given above.

The highlighted area in the Task Name window can be moved one line at a time, one page at a time, or to the beginning or end of the list using the [↑], [↓], [PG UP], [PG DN], [HOME], and [END] keys, respectively. Alternatively, to move directly to a particular task, type the task number and press the [ENTER] key.

To delete a task, move the highlighted area to the task and press the [DELETE] key. The task number continues to be displayed, but all data for the task is deleted.

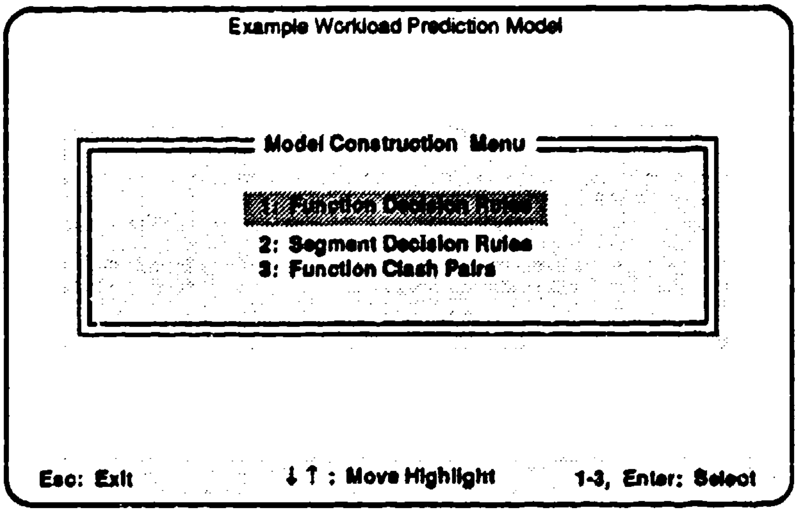
To edit data already entered, highlight the task and press the [ENTER] key. The procedure for editing is the same as entering new tasks. To leave the data in any window unchanged, press the [ESC] key.

When all tasks and the associated data are entered, press the [ESC] key to return to the Main Menu.

3 MODEL CONSTRUCTION

The model is a description of the sequencing and interactions of crewmembers' activities. It is constructed by entering decision rules that describe how the tasks and functions will be combined during the simulation of a segment. The order that the tasks or functions are entered into the decision rules does not determine the order that they will be simulated. Only the information in the decision rules (i.e., start and duration) is used in scheduling.

Press the [3] key on the Main Menu to execute the Model Construction routine. This displays the Model Construction Menu.



The Model Construction routine has three different windows:

- Function Decision Rules,
- Segment Decision Rules, and
- Function Clash Pairs.

These windows are fully described in individual sections beginning on the next page.

1 FUNCTION DECISION RULES

Press the [1] key in the Model Construction Menu to enter or edit the Function Decision Rules. This opens the Function Decision Rules window.

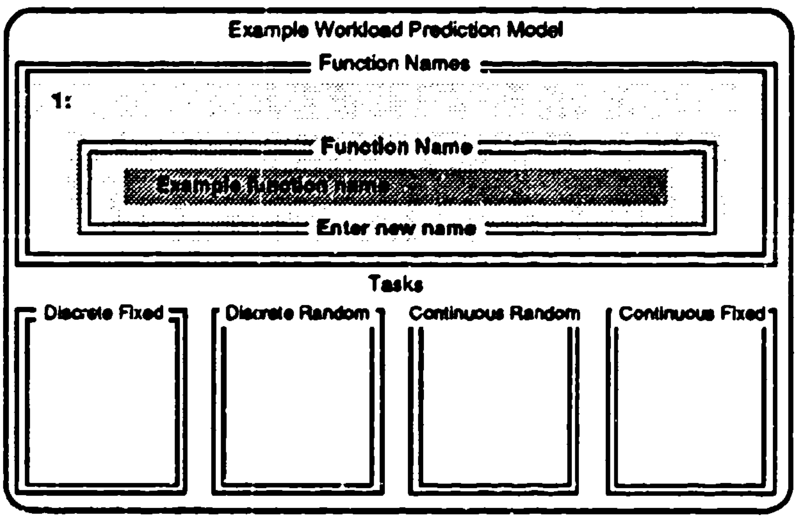
The Function Decision Rules routine has five different windows:

- Function Name,
- Discrete Fixed Tasks,
- Discrete Random Tasks,
- Continuous Random Tasks, and
- Continuous Fixed Tasks.

These windows are fully described in individual sections that follow.

FUNCTION NAME

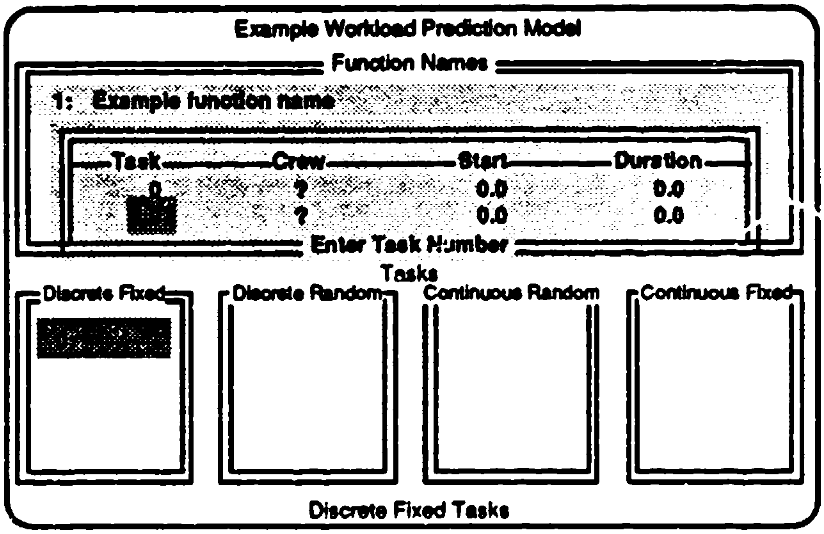
Press the [ENTER] key to enter the name of the first function. The Function Name window opens with a prompt for the function name.



Enter the function name (up to 66 alphanumeric characters) and press the [ESC] key to save the name and close the window. The highlighted area moves to the Discrete Fixed column. To insert a task, use the [←] or [-` key to move the highlighted area to the type of task (i.e., Discrete Random, Continuous Random, Continuous Fixed) and press the [INSERT] key.

DISCRETE FIXED TASKS

To insert a discrete fixed task into the function decision rule, press the [INSERT] key when the Discrete Fixed column is highlighted and the Discrete Fixed Task window opens.



The highlighted area is located under the **TASK** column in the window. Type the task number and press the [ENTER] key. The highlighted area moves to the **CREW** column and the valid code(s) for crewmember(s) entered in the Model Parameters is displayed at the bottom of the window.

Type the crewmember code and press the [ENTER] key to move to the **START** column.

The start time for a task within a function can be expressed in two ways: either as the absolute number of seconds from the start of the function or as the completion of a preceding task.

To indicate that a task is to begin 10 seconds from the beginning of a function, enter 10.0 and press the [ENTER] key to move to the **DURATION** column.

To indicate that a task is to begin after task number 5, enter a -5 and press the [ENTER] key to move to the **DURATION** column.

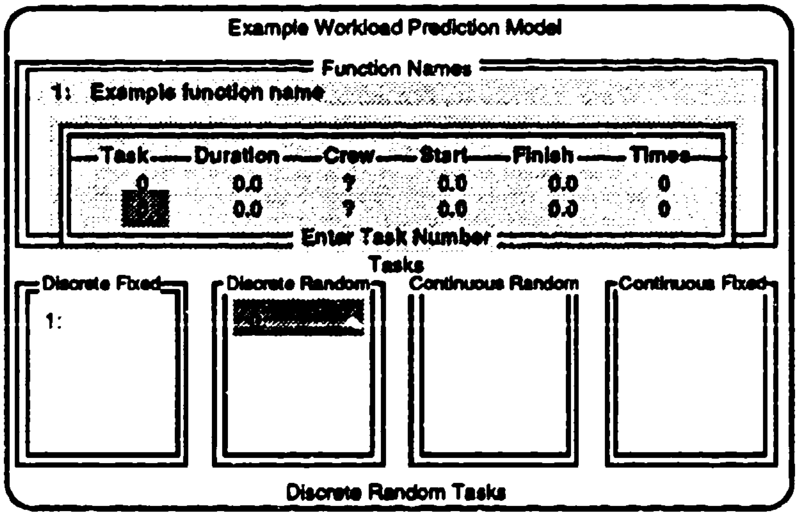
Enter the task duration in seconds and press the [ENTER] key. The highlighted area returns to the **TASK** column. To save the task information and close the window, press the [ESC] key.

To enter another task, press the [INSERT] key and follow the procedures given above. Continue this process until all discrete fixed tasks are entered.

DISCRETE RANDOM TASKS

Press the [→] key and the highlighted area moves to the Discrete Random column.

To insert a discrete random task into the function decision rule, press the [INSERT] key and the Discrete Random Task column opens.



Enter the task number in the **TASK** column and press the [ENTER] key to move to the **DURATION** column. Enter the task duration in seconds and press the [ENTER] key to move to the **CREW** column. Enter the code of the crewmember who performs the task and press the [ENTER] key to move to the **START** column. Enter the time the task may start to occur during the function and press the [ENTER] key to move to the **FINISH** column. Enter the end of the time the task may occur during the function. Use the code -0.5 to indicate that the task may occur until the function ends. Press the [ENTER] key to move to the **TIMES** column. Enter the number of times the random task is expected to occur between the **START** and the **FINISH** time and press the [ENTER] key.

To save the information, close the window, return to the Discrete Random column, and press the [ESC] key.

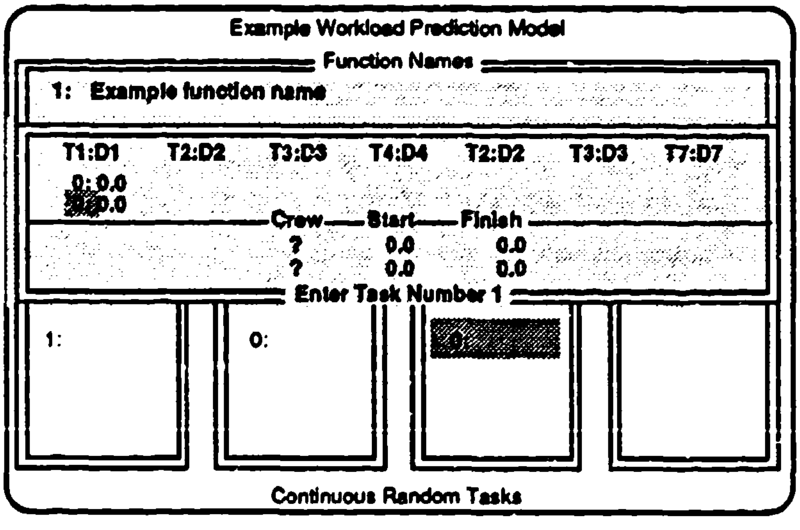
Continue the above process until all discrete random tasks are entered.

CONTINUOUS RANDOM TASKS

Press the [→] key and the highlighted area moves to the Continuous Random column. To insert a continuous random task set into the function decision rule, press the [INSERT] key and the Continuous Random Task window opens.

Tasks from the continuous random task set are constantly being selected during the active period defined by the start and finish fields. Type the first task number under **T1** and press the [ENTER] key to move to the duration column (**D1**). Type the duration of the task and press the [ENTER] key.

The highlighted area moves to the **CREW** column. Type the crewmember code and press the [ENTER] key to move to the **START** column. Type the start time and press the [ENTER] key to move to the **FINISH** column. Type the finish time and press the [ENTER] key. This completes entry of the first task.



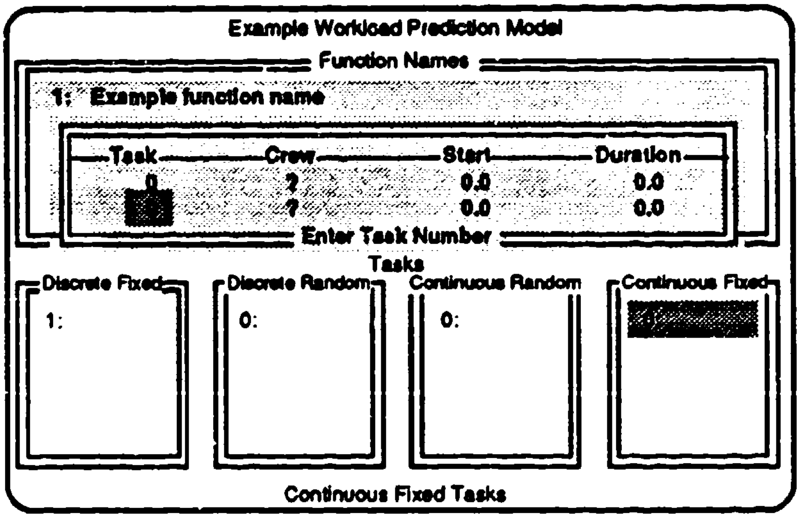
To enter a second task, press the [INSERT] key. The highlighted area moves under the second task column (**T2**). Type the task number and press the [ENTER] key to move to the duration column (**D2**). Type the duration for the second task and press the [ENTER] key. The highlighted area moves to the crew column again; however, it is not necessary to reenter the crew, start, and finish data. Press the [INSERT] key to enter other tasks in the set.

Continue this process until all tasks in the continuous random set are entered and press the [ESC] key to close the window and return to the Continuous Random column.

CONTINUOUS FIXED TASKS

Press the [→] key and the highlighted area moves to the Continuous Fixed column. To insert continuous fixed tasks into the function decision rule, press the [INSERT] key and the Continuous Fixed Task window opens.

The procedure for entering the Continuous Fixed tasks is the same as for entering the Discrete Fixed tasks.



Type the task number in the **TASK** column and press the [ENTER] key to move to the **CREW** column. Type the crewmember code and press the [ENTER] key to move to the **START** column. Type the start time and press the [ENTER] key to move to the **DURATION** column. Type the duration time and press the [ENTER] key to return to the **TASK** column.

Press the [ESC] key when the task data entry is complete to save the data and close the Continuous Fixed Task window. To enter another task, press the [INSERT] key and follow the procedures given above.

When all tasks are entered into the function decision rule, press the [ESC] key to save the data and return to the Function Names window. The **SAVE THE CHANGES TO FUNCTION #1? Y** prompt is displayed. Press the [Y] or [N] key that is appropriate, followed by the [ENTER] key.

To enter additional functions from the Function Names window, press the [INSERT] key and follow the procedures for entering the first function. To edit the function previously entered, highlight the function name and press the [ENTER] key.

After all function decision rules are entered and edited, press the [ESC] key to return to the Model Construction Menu.

SEGMENT DECISION RULES

Press the [2] key on the Model Construction Menu to enter or edit the Segment Decision Rules. This opens the Segment Decision Rules window.

The Segment Decision Rules routine has four different windows:

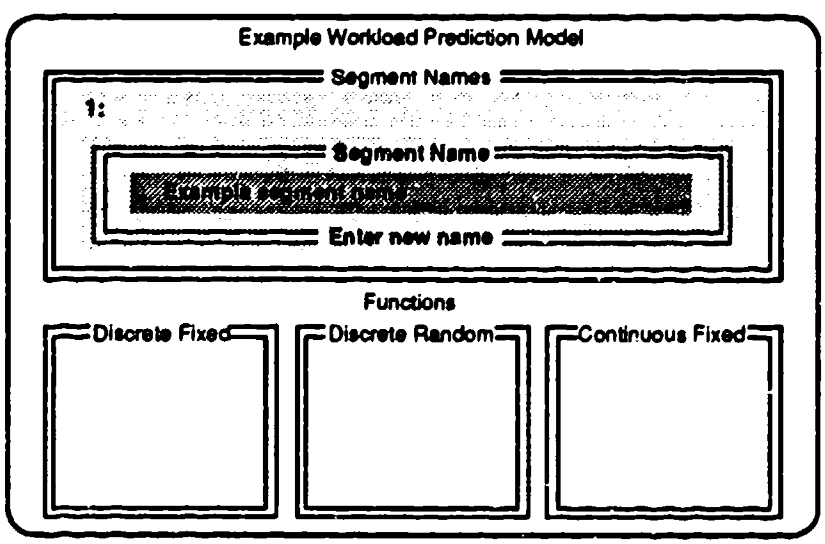
- Segment Name,
- Discrete Fixed Functions,
- Discrete Random Functions, and
- Continuous Fixed Functions.

These windows are fully described in individual sections that follow.

SEGMENT NAME

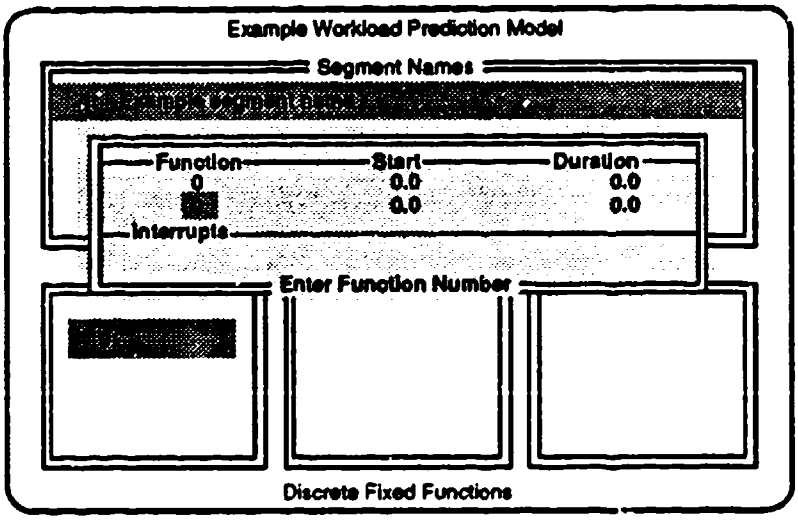
Press the [ENTER] key to enter the name of the first segment. The Segment Name window is displayed with a prompt for the segment name.

Enter the segment name (up to 66 alphanumeric characters) and press the [ESC] key to save the name and close the window. The highlighted area moves to the Discrete Fixed column. To insert a function, use the [←] or [→] key to move the highlighted area to the type of function (i.e., Discrete Fixed, Discrete Random, or Continuous Fixed) and press the [INSERT] key.



DISCRETE FIXED FUNCTIONS

To insert a discrete fixed function into the segment decision rule, press the [INSERT] key when the Discrete Fixed column is highlighted and the Discrete Fixed Function window opens.



Type the function number in the **FUNCTION** column and press the [ENTER] key to move to the **START** column.

The start time for a function within a segment can be expressed in two ways: as the absolute number of seconds from the start of the segment or as the completion of a preceding function.

To indicate that a function is to begin 30.0 seconds from the beginning of a segment, enter 30.0 and press the [ENTER] key to move to the **DURATION** column.

To indicate that a function is to begin after function number 10 ends, enter a -10 and press the [ENTER] key to move to the **DURATION** column.

Enter the function duration in seconds and press the [ENTER] key. The prompt moves below the **INTERRUPT** prompt.

DISCRETE FIXED FUNCTIONS (CONTINUED)

During a mission segment, a crewmember may halt the performance of one function, perform another to completion, then continue to perform the first function from the point of interruption. TOSS models these situations using interrupts. When any of the functions in the interrupt list are scheduled during the simulation of the current function, TOSS will, after the completion of the discrete tasks being performed, interrupt the current function. If there is a random function that interrupts this function, enter the interrupt function number at the **INTERRUPT** prompt and press the [ENTER] key. Up to 12 function numbers may be entered in the interrupt list. If all random functions interrupt the current function, indicate this by entering the code 9999 in the interrupt list. If no functions interrupt the discrete fixed function, press the [ENTER] key.

The highlighted area will return to the **FUNCTION** column. To save the function information and close the window, press the [ESC] key.

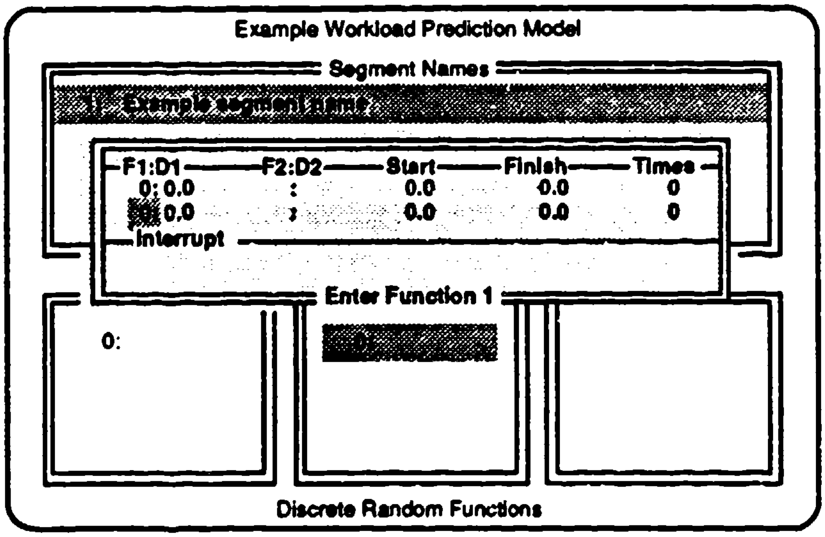
To enter another function, press the [INSERT] key and follow the procedures given above. Continue this process until all discrete fixed functions are entered.

When all entries that describe the discrete fixed functions are entered, press the [ESC] key to return to the Discrete Fixed column.

DISCRETE RANDOM FUNCTIONS

Press the [→] key to move the highlighted area to the Discrete Random column. To insert a discrete random function in the segment decision rule, press the [INSERT] key and the Discrete Random Function window opens.

Either one or two random functions can be entered in the Discrete Random Function window. If one function is entered, the program will select that function every time the function is scheduled for execution. If two functions are entered, the program will randomly select one of the functions each time the discrete random pair is scheduled for execution.



After pressing the [INSERT] key, the highlighted area will move to the **F1** column. Enter the function number and press the [ENTER] key to move to the **D1** column. Enter the length of time in seconds that the function will be performed when selected during the segment and press the [ENTER] key to move to the **F2** column. The procedure for entering the second function is the same as the procedure for entering the first function.

To enter only one function, press the [ENTER] key at the **F2** column. The highlighted area moves to the **START** column.

The start time that the random function may occur within the segment can be expressed in two ways: as the absolute number of seconds from the start of the segment or as the completion of a preceding function.

To indicate that the start time when the function may occur is 30.0 seconds from the beginning of a segment, enter 30.0 and press the [ENTER] key to move to the **FINISH** column.

DISCRETE RANDOM FUNCTIONS (CONTINUED)

To indicate that the start time when the function may occur is after function number 10 ends, enter a -10 and press the [ENTER] key to move to the **FINISH** column.

Enter the end of the time the function may occur during the segment. To extend the finish time to the end of the segment, enter the code -0.5. Press the [ENTER] key to move to the **TIMES** column. Enter the number of times the random function is expected to occur between the **START** and the **FINISH** time and press the [ENTER] key.

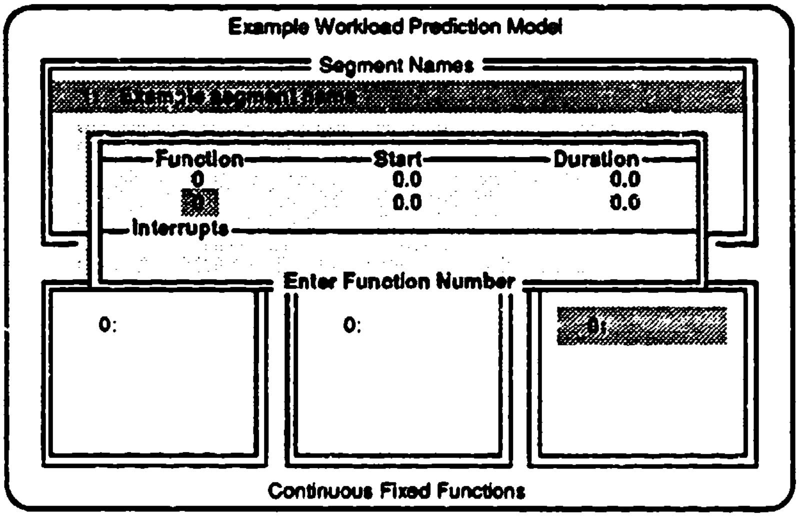
The highlighted area moves below the **INTERRUPT** prompt. Enter the function numbers that interrupt the current function during simulation and press the [ENTER] key.

To save the information and return to the **DISCRETE RANDOM** column, press the [ESC] key. Press the [INSERT] key to enter additional discrete random functions and follow the procedures given above. The current limit on the number of discrete random functions in a segment decision rule is 10.

Continue the above process until all discrete random functions are entered.

CONTINUOUS FIXED FUNCTIONS

Press the [→] key to move the highlighted area to the Continuous Fixed column. To insert a continuous fixed function into the segment decision rule, press the [INSERT] key. The Continuous Fixed Function window opens. The procedure for entering the continuous fixed functions is the same as the procedure for entering the discrete fixed functions.



Enter the function number in the **FUNCTION** column and press the [ENTER] key to move to the **START** column. Enter the start time and press the [ENTER] key to move to the **DURATION** column. Enter the duration and press the [ENTER] key to move to the **INTERRUPTS**. Enter the interrupt functions and press the [ENTER] key. See the section above on Discrete Random Functions for a description of all applicable codes.

To insert another function, press the [INSERT] key and continue as instructed above. After all continuous fixed functions are entered, press the [ESC] key to return to the Continuous Fixed column.

When all functions of all types are entered in the segment decision rule, press the [ESC] key to save the data and return to the Segment Names window. The **SAVE THE CHANGES TO SEGMENT #1? Y** prompt is displayed. Press the [Y] or [N] key that is appropriate, followed by the [ENTER] key.

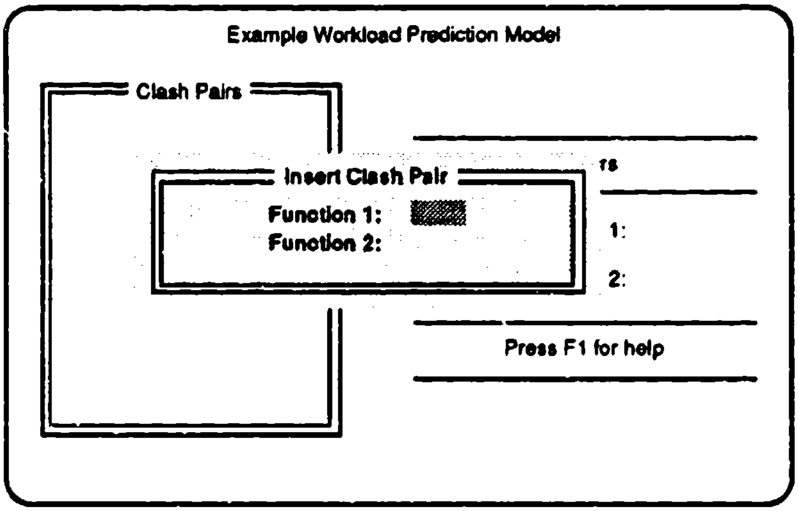
To enter additional segments from the Segment Names window, press the [INSERT] key and follow the procedures for entering the first segment. To edit the segment data previously entered, the procedure is the same as entering the data except the [ENTER] key is used to open the different windows after highlighting the data.

After all segment decision rules are entered and edited, press the [ESC] key to return to the Model Construction Menu.

3 FUNCTION CLASH PAIRS

Press the [3] key on the Model Construction Menu to enter or edit the Clash Pair file. This will open the Clash Pairs window.

To insert a Function Clash Pair, press the [INSERT] key. This will open the Insert Clash Pairs window.



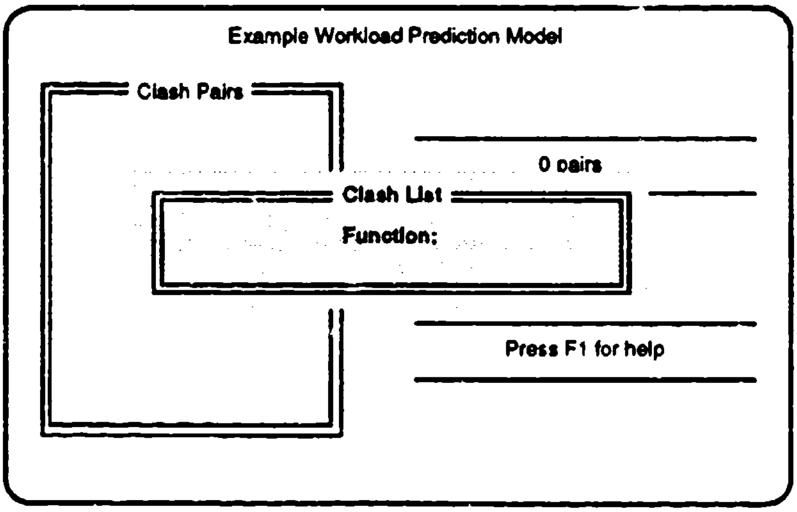
Enter the first function of the function clash pair and press the [ENTER] key to move to the **FUNCTION 2:** prompt. Enter the second function and press the [ENTER] key to return to the **FUNCTION 1:** prompt. To save the clash pair and return to the Clash Pairs window, press the [ESC] key.

Continue this procedure until all clash pairs are entered. To delete a pair, highlight the pair using the [↑] or [↓] key and press the [DELETE] key. To delete the pair, press the [Y] and [ENTER] keys in response to the prompt **DELETE PAIR #1? Y**. Press the [N] and [ENTER] keys to cancel the delete.

To locate a clash pair in the list, press the [F6] key. The Locate Clash Pair window opens. The Locate Clash Pair window is similar to the Insert Clash Pair window. Enter the first function number at the **FUNCTION 1:** prompt and press the [ENTER] key to move to the **FUNCTION 2:** prompt. Enter the second function number and press the [ENTER] key. The window closes and the requested pair is highlighted on the list. If the pair is not in the list, the message **FUNCTION CLASH PAIR NOT FOUND** flashes on the bottom of the window.

FUNCTION CLASH PAIRS (CONTINUED)

To obtain a list of the functions that clash with a particular function, press the [F5] key. The Clash List window opens.



Enter the function number at the **FUNCTION:** prompt and press the [ENTER] key. The window changes and displays all functions that clash with the function that was entered. Press any key to return to the Clash Pairs window.

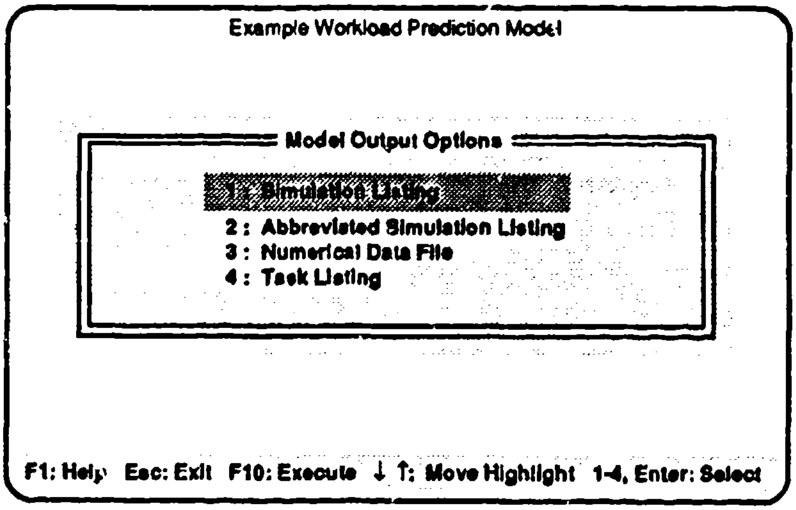
When all clash pairs have been entered, press the [ESC] key to return to the Model Construction Menu.

When all decision rules and clash pairs are entered and edited, press the [ESC] key to return to the Main Menu.

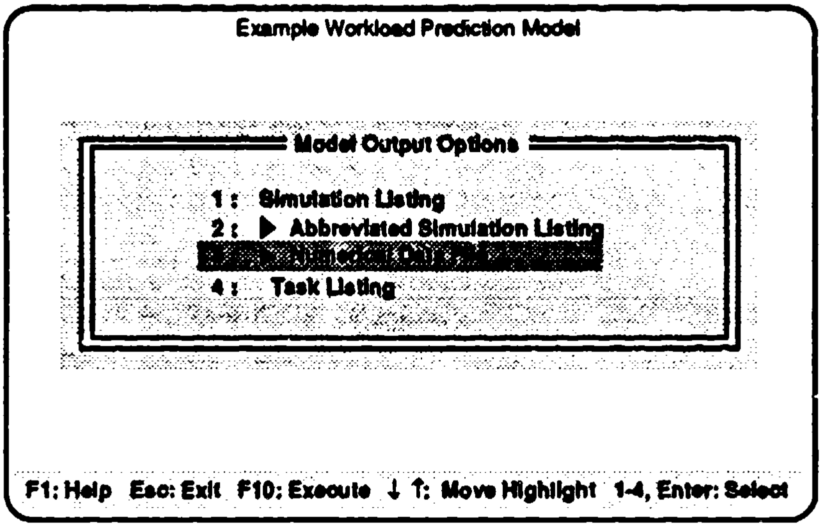
4 MODEL SIMULATION

After constructing and entering a complete model, each of the segments can be simulated. The algorithm used during simulation is described in detail in the logic flow diagrams presented in Appendix D.

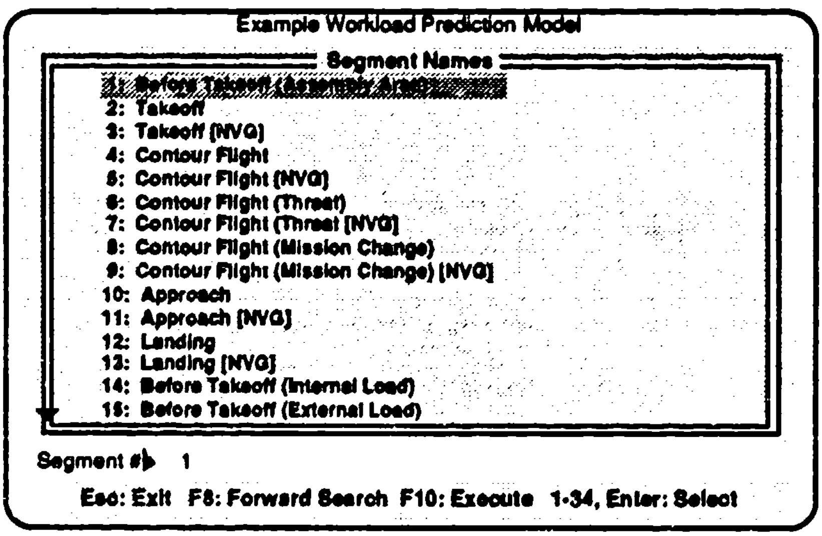
Press the [4] key on the Main Menu to execute the Model Simulation routine. This displays the Model Output Options Menu.



The output options are described in the following sections that begin with a diamond shape. Also, examples of each are presented in Appendix E. Determine the desired output and press the number key beside the appropriate option. This displays the Page Size window and the default page size for the output option. To change the number of lines on each page of the output, enter the new page size and press the [ENTER] key. To use the current page size and close the Page Size window, press the [ENTER] or [ESC] key. A right triangle appears beside the number, indicating the option is selected.

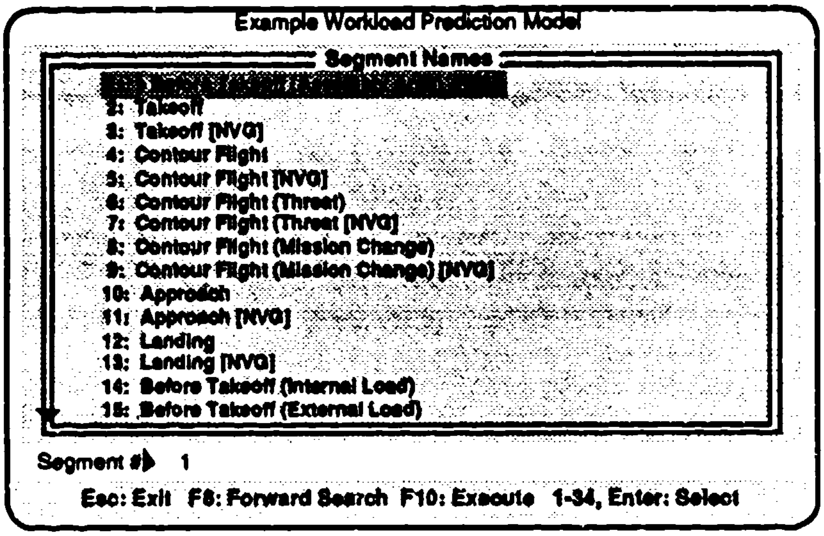


To turn off the option, press the number key next to the right triangle. Multiple options can be selected to create more than one type output file when the segment is simulated. After selecting the desired option(s), press the [F10] key to open the Segment Names window.

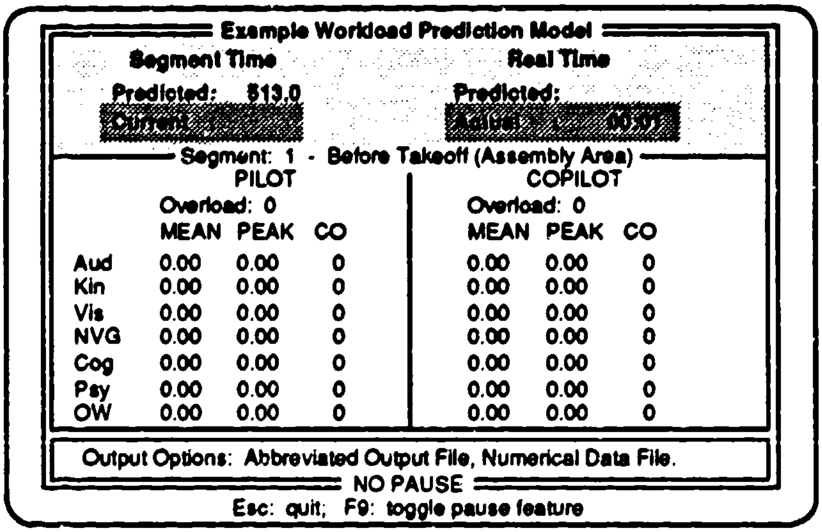


To select a segment for simulation, press the [↑] or [↓] key to highlight the desired segment and press the [ENTER] key or enter the number by the SEGMENT # ▶ prompt and press the [ENTER] key. A right triangle indicating a selected status is displayed next to the segment number. To deselect a segment, highlight it and press the [ENTER] key.

If more than one segment is to be executed, press the [↑] or [↓] key and follow the procedure above until all desired segments are selected. Press the [F3] key to select all segments or the [F4] key to deselect all segments. Press the [F10] key and the selected segments are simulated.



For all output options, the Model Simulation window is displayed. The file(s) being created is listed in the Output Options block.



A summary screen is displayed throughout the segment run. The screen displays the same information for all output options.

If any of the decision rules refer to a crewmember who is not currently defined in the model, the following message is displayed on the screen: **WARNING: TASK IN DECISION RULE HAS INVALID CREWMEMBER**. This is an advisory message and will not interrupt the segment simulation.

When the segment run is completed, the overload density is displayed for the segment and the **SEGMENT COMPLETED ... PRESS A KEY:** prompt is displayed. Press any key to return to the Segment Selection window.

The subsections that follow describe each of the types of output that can be generated by TOSS.

SCREEN OUTPUT

If no output options are selected, the simulation is performed without creating an output file. This is the fastest method of simulation. TOSS runs the model and displays the results only on the screen. The screen displays the segment time, the actual time to run the segment, the number of overload conditions and the overload density for each crewmember, the average workload by component, the peak workload by component, and the number of component overloads. To obtain a printout of the screen, use the [PRINT SCREEN] key to send a copy of the screen to the printer (see page E-2 of Appendix E).

1 SIMULATION LISTING

The Simulation Listing output lists each crewmember's current functions and the tasks within those functions for half-second periods along the mission timeline (see pages E-3 through E-5). This option produces a computer file in the model directory named SIM####.LST, where #### is replaced with the segment number preceded by zeros. For example, the output file for Segment 1 is SIM0001.LST. Task workload is printed for each task and the current workload total is printed for each crewmember. When a new overload condition occurs for a crewmember, the previous overload count is incremented by one and the current count of overload conditions is printed at the right of the page. The task subsystems for the overloaded crewmember are printed below the total line. TRANSITION is printed for the task when a crewmember makes a transition from one task to another task. STANDBY is printed in place of a function when a crewmember is not performing a function. If there is a component conflict (e.g., two tasks require the same hand), a star is printed next to the component total. The last half-second period in the segment timeline does not list a function or task and indicates the end of the segment.

The last several pages of the Simulation Listing output file present summary information. The first summary page (see page E-6) lists the state the model was in when the segment was simulated. It lists the currently defined workload components and thresholds and the current workload equation and threshold. It also lists the current state of the randomization parameters.

The second summary page (see page E-7) describes the workload experienced by each crewmember during the segment. The component workload statistics and the overload density are listed for each crewmember.

1 SIMULATION LISTING (CONTINUED)

The following summary pages, one page for each crewmember (see pages E-8 and E-9), describe the results of the simulation with respect to the subsystems. For each subsystem, the report lists the number of overload conditions associated with that subsystem and the percentage of segment time that the subsystem was used by the crewmember. The report also lists the mean component workload that the crewmember experienced while using the subsystem and the subsystem impact (SI = % utilization times mean workload).

The final summary page (see page E-10) lists the results from the simulation of random functions in five columns. The function number is listed in the first column. The user defined TIMES field from the segment decision rule is listed in the second column. The TIMES field contains the mean number of times the function is expected to occur. The third column lists the maximum number of times the random function could have occurred during simulation. This ceiling is calculated by multiplying the expected number of occurrences by 1.5. The lower limit of occurrence is set at zero. The fourth column is the number of times the random function actually occurred during simulation. The final column lists the additional number of times the function could have occurred before reaching the ceiling.

2 ABBREVIATED SIMULATION LISTING

The Abbreviated Simulation Listing output is similar to the Simulation Listing output except that it prints fewer half-second periods. For example, the Abbreviated Simulation Listing does not print a representation when a new continuous random task is selected. A new point on the timeline is printed only if a discrete fixed or a discrete random task changes, or if a new continuous random task creates an overload condition. This option produces a computer file in the model directory named ABS####.LST.

3 NUMERICAL DATA FILE

The Numerical Data Files output (see page E-11) enables further analyses of the model output (e.g., statistical analysis or graphing). This option produces separate computer files in the model directory for each of the crewmembers defined in the model by combining the single letter crewmember code and WL####.LST. For example, if the currently defined crewmember codes in the model are P and C, then this option would produce the files PWL####.LST and CWL####.LST.

3 NUMERICAL DATA FILE (CONTINUED)

The current predictions of each crewmember's workload are written into these files for each half-second of the segment.

The Numerical Data Files differ from the Simulation Listing output in two ways. First, the files do not contain any description of the tasks or functions being performed during the segment; the files only contain numbers (workload predictions). Second, every half-second of the model execution is represented by a new row of predictions. The first column in the file is always the segment time and is followed by the model's predictions of the crewmember's current workload for each of the components defined in the model. The final column is generated by the workload equation. The files are tab delimited ASCII, which is compatible with most text editors and statistical software.

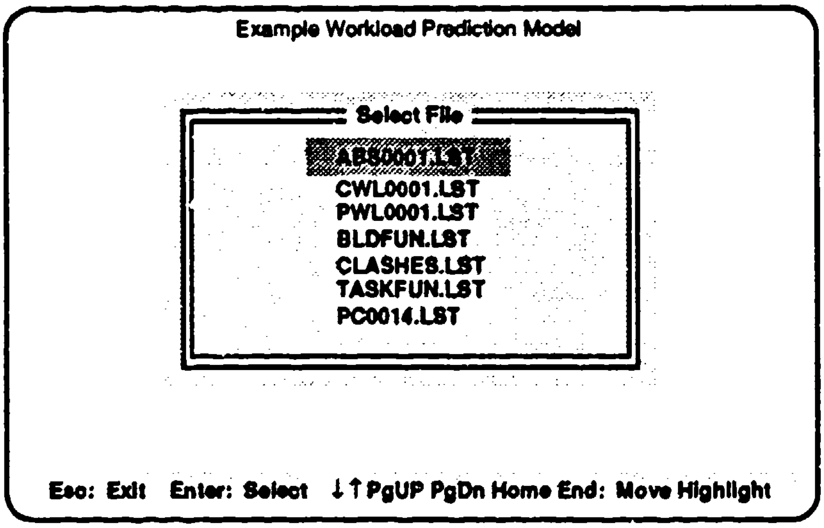
4 TASK LISTING

The Task Listing output (see page E-12) was created to facilitate a review of the simulation by experienced personnel to determine the accuracy of the model. The Task Listing output lists only the segment time and current task(s) being performed by the crewmembers and has no information about the function or the workload. This option produces a computer file in the model directory named by combining the single letter crewmember codes and ####.LST. For example, if the currently defined crewmember codes in the model are P and C, then this option produces the file PC####.LST.

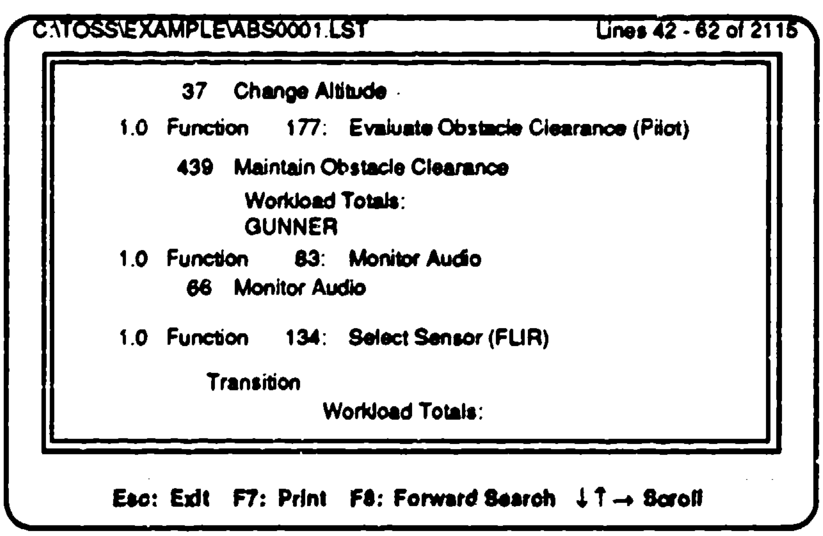
Each output option produces a unique file (or set of files) in the model directory. Thus, each time the Model Simulation routine is entered and a particular output option is chosen, the program produces a unique file with the segment number (e.g., ABS0001.LST, ABS0002.LST, ABS0003.LST for segments 1, 2, and 3).

5 VIEW/PRINT OUTPUT

Press the [5] key on the Main Menu to review or print any of the output files. The Select File window is displayed with a list of the viewable/printable files in the model subdirectory.

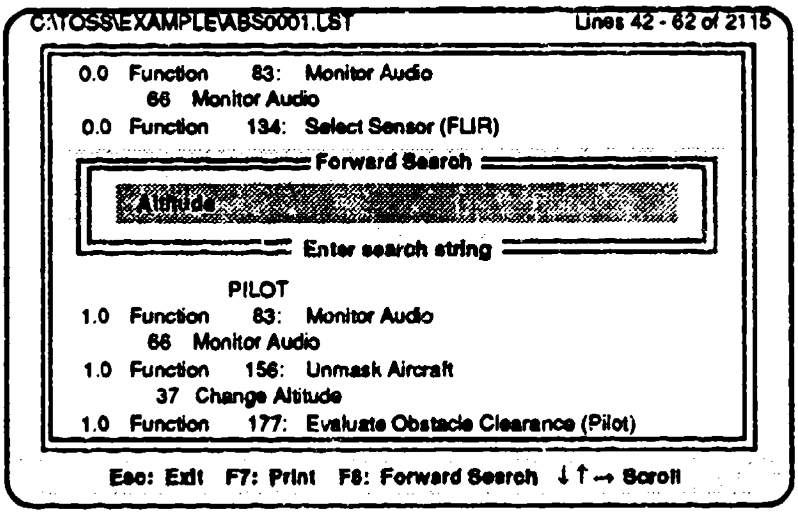


Press the [↑] or [↓] to scroll the highlighted area through the list to the output file you want to review. Press the [ENTER] key and the file is displayed.



The full path and file name is displayed at the top left corner of the window. The line numbers of the portion of the file currently displayed and the total number of lines in the

file are listed at the top right corner of the window. The [↑], [↓], [→], and [←], [PG UP], [PG DN], [HOME], and [END] keys can be used to scroll file for viewing on the screen. Press the [F7] key to print the file. If the printer is not available, a pop-up window with **PRINTER NOT READY ... CHECK PRINTER AND TRY AGAIN!** will be displayed. If the printer is available when the [F7] key is pressed, the message **PRINT THE ENTIRE FILE? Y** will be displayed. Press the [ENTER] key and the entire file will be sent to the printer. Press the [N] key, followed by the [ENTER] key, and a pop-up window with **ENTER FIRST PAGE # AND ENTER LAST PAGE #** is displayed. Enter the first page number and press the [ENTER] key. Enter the last page number or an [*] for end of file and press the [ENTER] key to send the designated pages to the printer.



Press the [F8] key to search for a string of characters in the file. The Forward Search window opens. Type the string of characters in the window and press the [ENTER] key to begin the search for the string. If the string is found, the search will stop, highlighting the string in the file. To quickly search for the same string again, press the [F8] key again (notice that the previous search string remains in the Forward Search window), then press the [ENTER] key. The search for the string begins at the top of the screen that is currently displayed and only proceeds forward in the file. If the string is not found, a bell sounds and an error message is displayed.

To exit the routine, press the [ESC] key to return to the Main Menu. To review other files, press the [5] key to return to the Select File window.

6 Report Generation

Press the [6] key on the Main Menu to execute the Report Generation routine. This displays the Output Options Menu.

```
                 Example Workload Prediction Model

              ========= Output Options =========
                 1: Send Output to Printer
                 2: Send Output to File
                 3: Send Output to Printer and File

Esc: Exit          ↓ ↑ : Move Highlight         1-3, Enter: Select
```

Prior to generating any reports, TOSS needs to know how to direct the output. TOSS can direct its output to go directly to the printer, into a file, or to both. To select an output option, scroll the highlighted area with the [↑] or [↓] key and press the [ENTER] key or press the number key that is displayed next to the output option. This displays the Page Size window. Enter the number of lines per page and press the [ENTER] key or press the [ESC] key to accept the current page size. This displays the Report Generation Menu.

```
                 Example Workload Prediction Model

              ========= Report Menu =========
                 1: Task Data Base
                 2: Function Names
                 3: Function Decision Rules
                 4: Segment Names
                 5: Segment Decision Rules
                 6: Function Clash Pairs
                 7: Task Cross-Reference
                 8: Function Cross-Reference

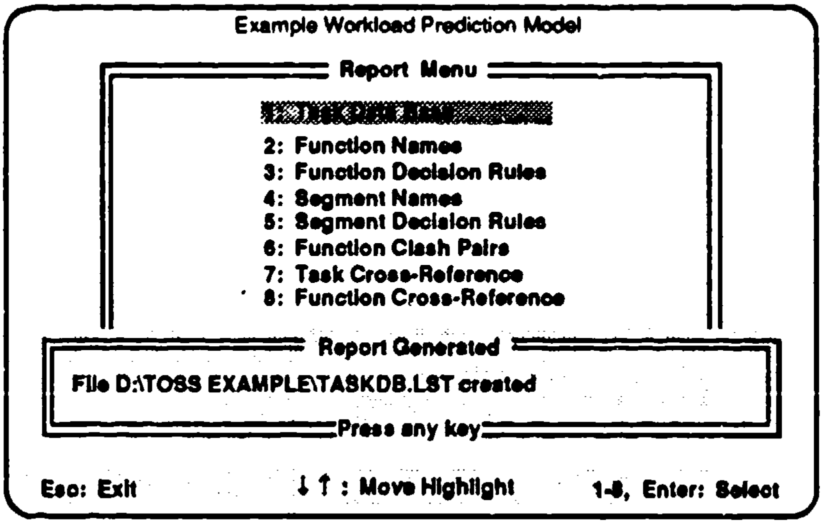
Esc: Exit          ↓ ↑ : Move Highlight         1-8, Enter: Select
```

To select one of the reports listed, scroll the highlighted area with the [↑] or [↓] key to the desired report and press the [ENTER] key or press the number key that is displayed next to the file name. Examples of the output produced for each of the reports are presented in Appendix F. The instructions for generating the reports are given below.

1 TASK DATA BASE

Press the [1] key on the Report Generation Menu to generate a report of all tasks and the associated subsystems and workloads. The prompt **DO YOU WANT TO ALPHABETIZE THE LISTING? Y** is displayed. To generate an alphabetical task listing, press the [ENTER] key. Otherwise, press the [N] key, followed by the [ENTER] key, and a report is generated listing tasks by number. The Task Data Base report contains all the tasks in the model with associated task number, subsystem(s), and component workload(s). Use the View/Print Output option on the Main Menu to view the file on the screen.

If option 2 or 3 of the output options is chosen from the Output Options Menu, the Report Generated window will open.



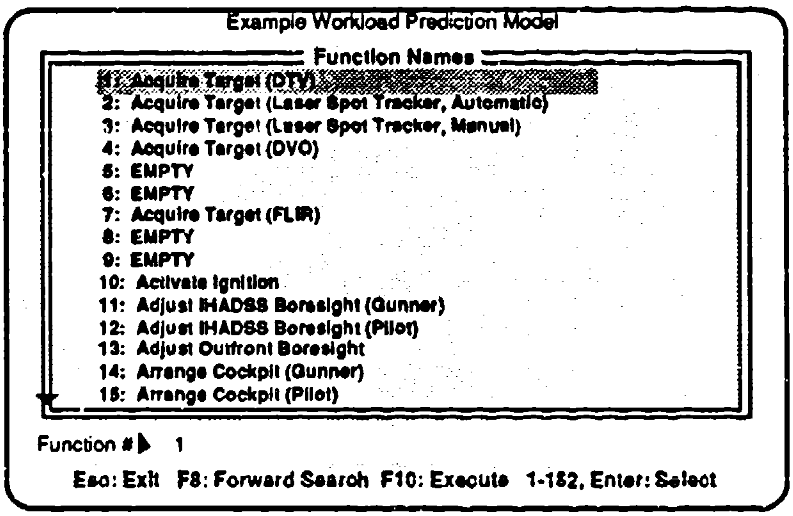
TOSS will pause, displaying the complete file name of the report file that was created. After noting the name of the file, press any key to continue. The default file name for the Task Data Base Report is TASKDB.LST.

② FUNCTION NAMES

To generate a report listing all the function names and numbers, press the [2] key on the Report Generation Menu and follow the instructions given for the Task Data Base. The default file name for the Function Names Report is FUNCTION.LST.

③ FUNCTION DECISION RULES

Press the [3] key on the Report Generation Menu to generate a report of the information in one or more decision rules. The functions in the model are listed numerically in the Function Names window.



The number next to the **FUNCTION # ▶** prompt is the function that is highlighted on the list. To change the number, scroll through the list using the [↑], [↓], [PG UP], [PG DN], [HOME], or [END] key or enter the desired function number. Press the [ENTER] key and a right triangle is displayed next to the number in the list. This identifies the function decision rule to be output. Press the [F3] key to select all functions. Press the [F4] key to deselect all functions.

After identifying the desired functions, press the [F10] key to generate a report of the designated Function Decision Rules. The default file name for the Function Decision Rules Report, BLDFUN.LST, is displayed in the Report Generated window. Press any key to return to the Report Menu window.

SEGMENT NAMES

To generate a report listing all the segment names and numbers, press the [4] key on the Report Generation Menu and follow the instructions given for the Task Data Base. The default file name for the Segment Names Report is SEGMENT.LST.

SEGMENT DECISION RULES

Press the [5] key on the Report Generation Menu to generate a report of the information in one or more segment decision rules. The Segment Names window is displayed.

The procedure for selecting the desired segments is the same as that given above for selecting functions. The default file name for the Segment Decision Rules Report is BLDSEG.LST.

```
                 Example Workload Prediction Model
                          Segment Names
      1: Before Takeoff (Assembly Area)
      2: Takeoff
      3: Takeoff [NVG]
      4: Contour Flight
      5: Contour Flight [NVG]
      6: Contour Flight (Threat)
      7: Contour Flight (Threat [NVG]
      8: Contour Flight (Mission Change)
      9: Contour Flight (Mission Change) [NVG]
     10: Approach
     11: Approach [NVG]
     12: Landing
     13: Landing [NVG]
     14: Before Takeoff (Internal Load)
     15: Before Takeoff (External Load)
Segment #▶ 1
   Esc: Exit  F8: Forward Search  F10: Execute  1-34, Enter: Select
```

6 FUNCTION CLASH PAIRS

Press the [6] key on the Report Generation Menu to generate a report of the clash pairs. The Report Generated window pauses, displaying the default file name for the Clash Pair Report: CLASHES.LST. Press any key to return to the Report Menu. Return to the Main Menu and use the View/Print Output to view the file on the screen.

7 TASK CROSS-REFERENCE

Press the [7] key on the Report Generation Menu to execute the Task Cross-Referance option. This option generates a report that, for each task, lists all the functions that contain that task. The Report Generated window pauses, displaying the default file name for the Task Cross-Reference Report: TASKFUN.LST. Press any key to return to the Report Menu. To view the file on the screen, return to the Main Menu and use the View/Print Output option.

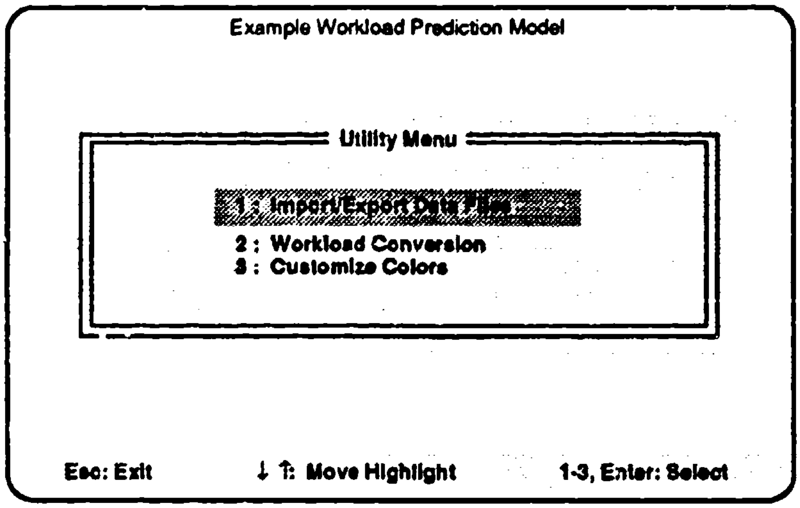
8 FUNCTION CROSS-REFERENCE

Press the [8] key on the Report Generation Menu to execute the Function Cross-Reference option. This option generates a report that, for each function, lists all the segments that contain that function. The Report Generated window pauses, displaying the default file name for the Function Cross-Reference Report: FUNSEG.LST. Press any key to return to the Report Menu. To view the file on the screen, return to the Main Menu and use the View/Print Output option.

7 UTILITIES

There are three utilities that may be useful during the creation and development of a TAWL model. These utilities allow the user to import or export TOSS data files to dBASE files, change the workload rating scales used in the workload analysis, or change TOSS screen colors.

Press the [7] key on the Main Menu to execute the Utilities routine. This displays the Utility Menu.



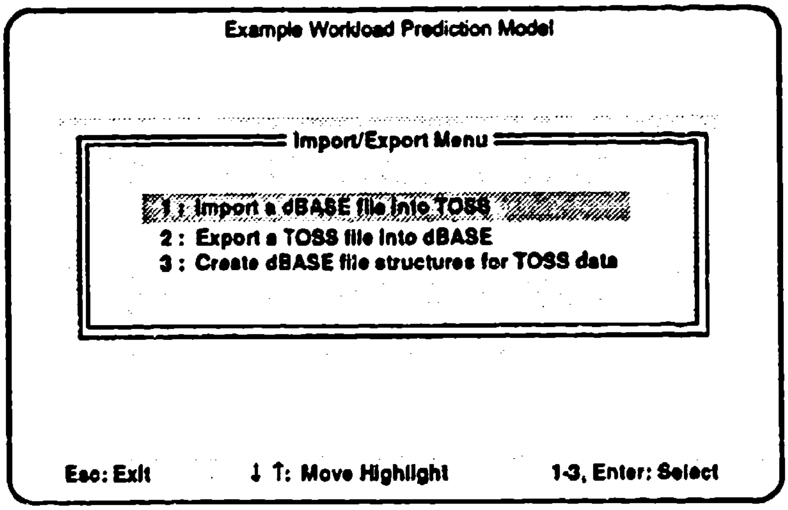
The Utilities routine has three different options:

- Import/Export Data Files,
- Workload Conversion, and
- Customize Colors.

These options are fully described in individual sections beginning on the next page.

IMPORT/EXPORT DATA FILES

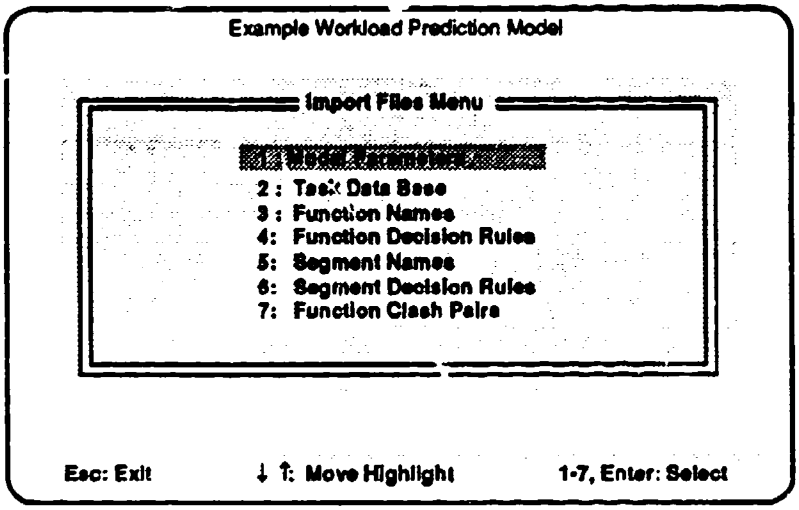
Press the [1] key on the Utilities Menu to import or export TOSS data to dBASE files. This displays the Import/Export Menu.



IMPORT A dBASE FILE INTO TOSS

Press the [1] key on the Import/Export Menu to import existing data in dBASE format into a TOSS model. See Appendix G for a full description of the dBASE file names and structures for TOSS data. This displays the Import Files Menu.

IMPORT A dBASE FILE INTO TOSS (CONTINUED)

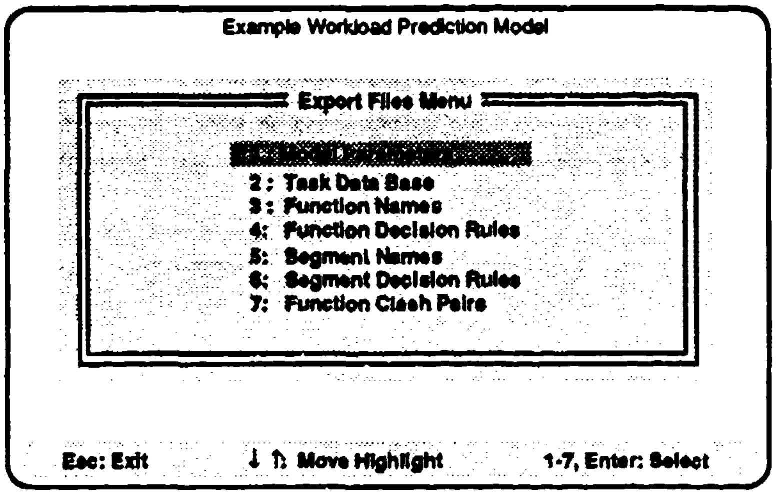


CAUTION: Selecting an item from this menu destroys the corresponding TOSS data. When there are existing dBASE files in the model directory with the correct names and file structures, selecting any one of the items from the Import Files Menu causes TOSS to read the dBASE file and replace the current TOSS data with the data found in the dBASE file. Prior to importing the data, TOSS displays a Warning window and allows you to abandon the operation.

EXPORT A TOSS FILE INTO dBASE

Press the [2] key on the Import/Export Menu to export existing TOSS data to dBASE format files. This displays the Export Files Menu. See Appendix G for a full description of the dBASE file names and structures for TOSS data.

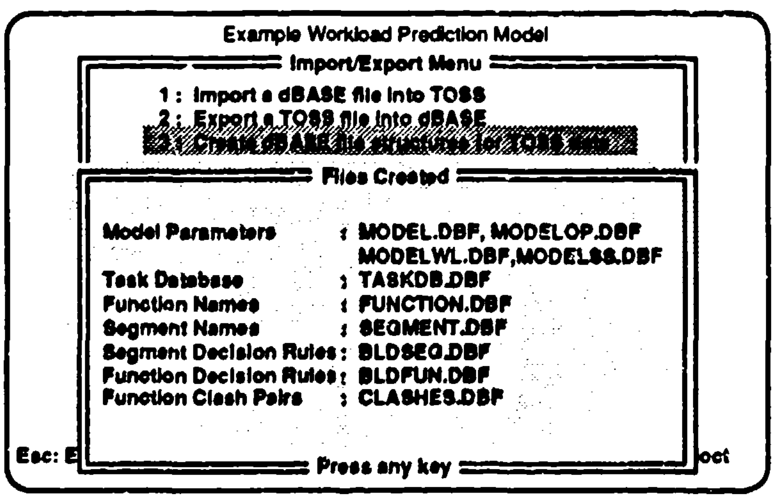
2 EXPORT A TOSS FILE INTO dBASE (CONTINUED)



To create a dBASE file containing the current model data, select any of the items on the Export Files Menu. TOSS creates a dBASE file in the model directory and pause to identify the file(s) that were created.

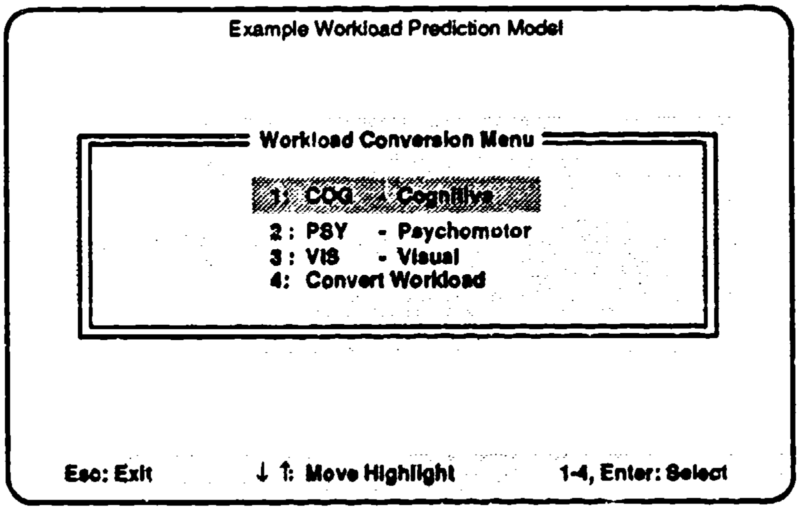
3 CREATE dBASE FILE STRUCTURES FOR TOSS DATA

Press the [3] key on the Import/Export Menu to create empty dBASE files structured for TOSS data. See Appendix G for a full description of the dBASE file names and structures for TOSS data. This opens the Files Created window displaying the dBASE file names that were created.



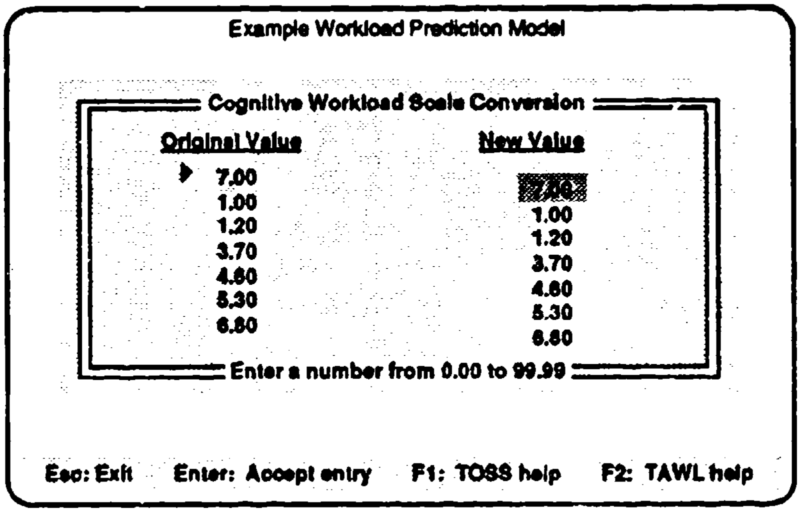
WORKLOAD CONVERSION

Press the [2] key on the Utilities Menu to convert the workload ratings in a model from one scale to another. This displays the Workload Conversion Menu. The Workload Conversion Menu differs, depending on the workload components that are identified in the model parameters of the model. An example Workload Conversion Menu is given below.



As indicated by the menu, the Example Workload Prediction Model has three workload components: cognitive, psychomotor, and visual. Each of the workload component selections on the Workload Conversion Menu allows the rating scale for that component to be mapped onto a different scale. For example, if the first item (1: COG - Cognitive) on the menu was selected by pressing the [1] key or highlighting it and pressing [ENTER], the Cognitive Workload Scale Conversion window would open.

WORKLOAD CONVERSION (CONTINUED)



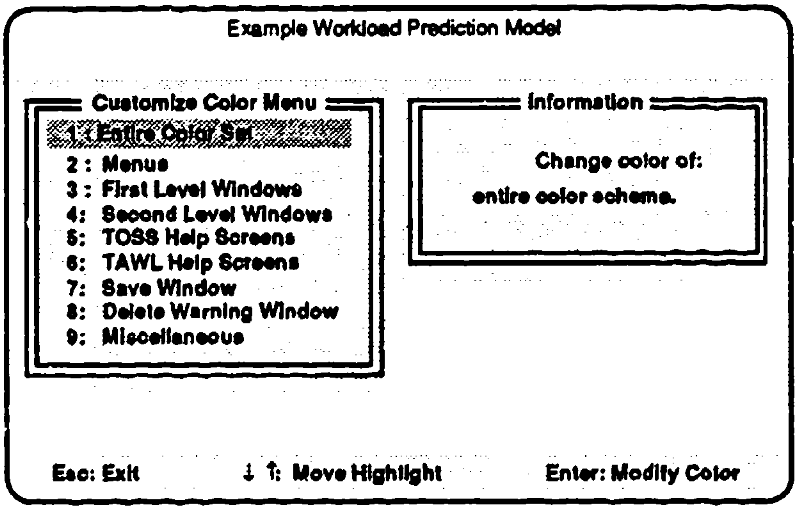
This window identifies all the unique values found in the cognitive workload ratings entered in the Task/Workload Analysis routine. These values are listed in the column labeled Original Value. Beside that column is a column labeled New Value where, initially, the original values are listed.

If, for sake of demonstration, you wanted to use this routine to double all the cognitive ratings in a model, you would enter 14.00 beside the original value of 7.00, 2.00 beside the original value of 1.00, 2.40 beside the original value of 1.20, etc. After entering the new mapping in the Cognitive Workload Scale Conversion window, you would press the [ESC] key to return to the Workload Conversion Menu window. Selecting the last item on the menu (i.e., Convert Workload) would cause TOSS to replace all the original cognitive workload ratings with the new ones you entered.

This utility was quite useful when models, developed using ordinal rating scales, were updated to use equal-interval rating scales. The routine is capable of producing any many-to-one or one-to-one mapping functions to convert from one workload rating scale to another as long as the new values range from 0.00 to 99.99.

CUSTOMIZE COLORS

Press the [3] key on the Utilities Menu to change the colors used in TOSS display screens. This displays the Customize Colors Menu.



The first item on the Customize Color Menu (Entire Color Set) allows you, in a single keystroke, to change all of the colors used to display information in TOSS. There are two options for complete color sets: the Monochrome Color Set and the Default Color Set. To change the color set to one of these schemes, highlight the Entire Color Set option on the Customize Color Menu and press the [ENTER] key. This displays the Entire Color Set Menu.

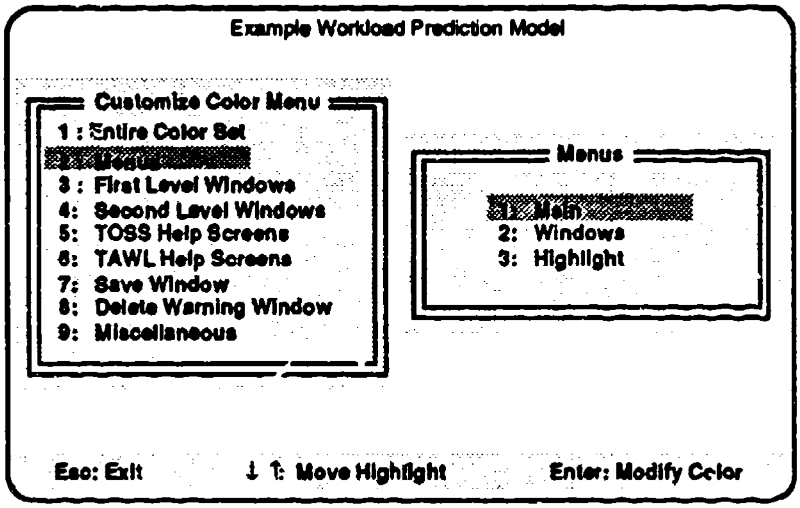
To change the display of information in TOSS so that it is best visible on a monochrome display, highlight the Monochrome option on the menu and press the [ENTER] key.

To change the display of information in TOSS to the original color set, highlight the Default option and press the [ENTER] key.

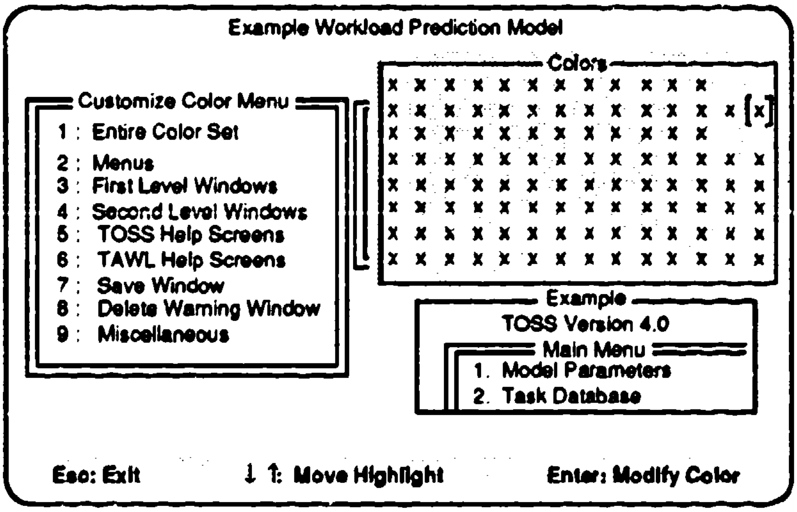
The remainder of the options on the Customize Color Menu are used to change the display characteristics of the 48 different types of information displayed by the program. The procedures for changing the 48 different colors are similar; thus, only one example is described.

CUSTOMIZE COLORS (CONTINUED)

To change the color of menus, select the Menus option from the Customize Color Menu. TOSS displays the Menus window.



Select the windows option either by highlighting and pressing the [ENTER] key or by pressing the [2] key. This opens the Colors and Example windows.



Use the [↑], [↓], [→], or [←] key to select the color in the Color window. To aid in color selection, the Example window displays the selected color scheme. When color selection is complete, press the [ENTER] key to return to the Menus window. Press the [ESC] key to return to the Customize Colors Menu.

CUSTOMIZE COLORS (CONTINUED)

Use the same procedure to change the colors of any of the other items on the Customize Colors Menu.

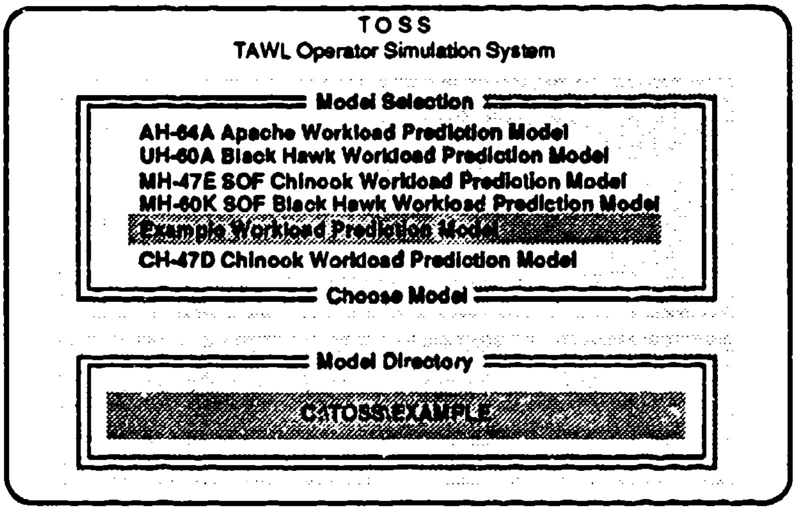
Press the [ESC] key to return to the Utilities Menu. TOSS asks for confirmation on the changes made to the color scheme. To save the changes, press the [ENTER] key; to discard them, press the [N] key, followed by the [ENTER] key.

When the use of the utilities is completed, press the [ESC] key on the Utility Menu to return to the Main Menu.

8 Model Selection

The Model Selection routine can be used to select, create, delete, back up, and restore models.

Press the [8] key on the Main Menu to execute the Model Selection routine. This opens the Drive Selection window. Enter the single letter designation of the computer disk where the model is stored and press the [ENTER] key. This opens the Model Selection window.



The Model Selection routine has five different windows:

- Model Selection,
- Model Creation,
- Model Deletion,
- Model Backup, and
- Model Restoration.

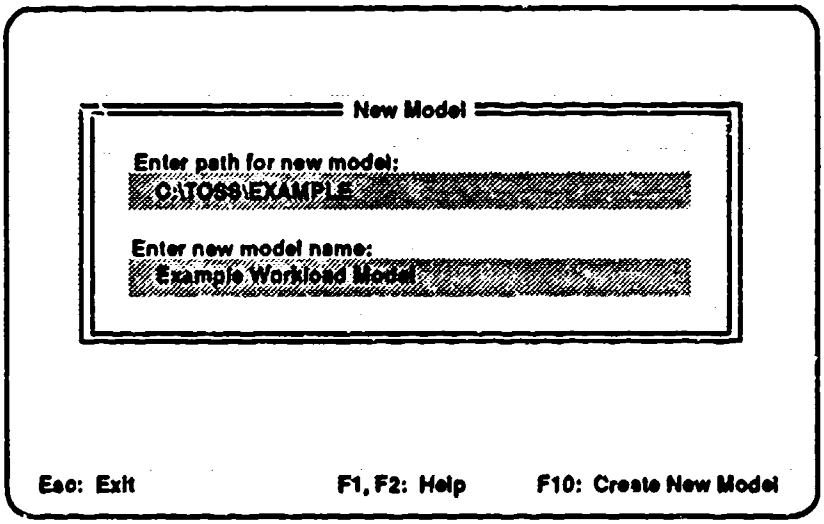
These windows are fully described in individual sections beginning on the next page.

MODEL SELECTION

To select a model, highlight the model using the [↑] or [↓] key. The content of the Model Directory window changes as different models are selected in the Model Selection window, indicating the disk directory that contains the model data files. To begin working with a model, highlight it and press the [ENTER] key; to execute one of the other model level actions, follow the instructions below.

MODEL CREATION

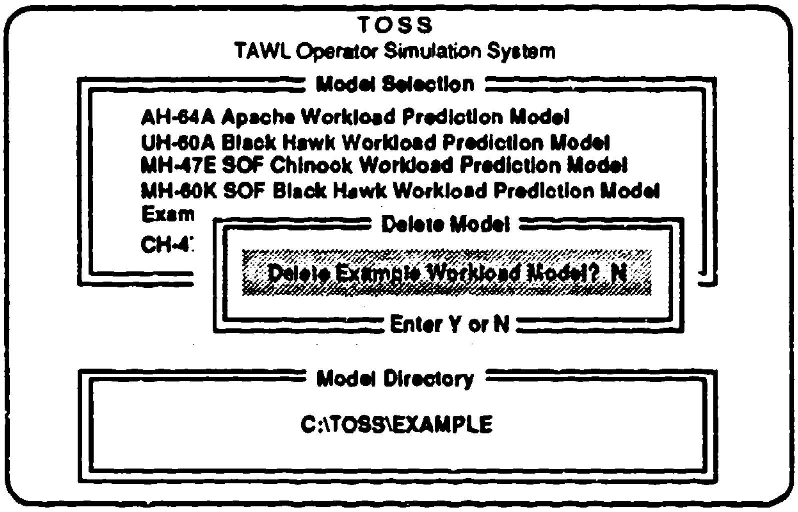
To create a new model from the Model Selection window, press the [INSERT] key. This opens the New Model window.



Enter the new model subdirectory and press the [ENTER] key. Enter the new model name, then press the [ENTER] key. Press the [F10] key to create the new model; to abandon the creation of the new model, press the [ESC] key. The Model Selection window then opens with the new model name in the list of available models.

MODEL DELETION

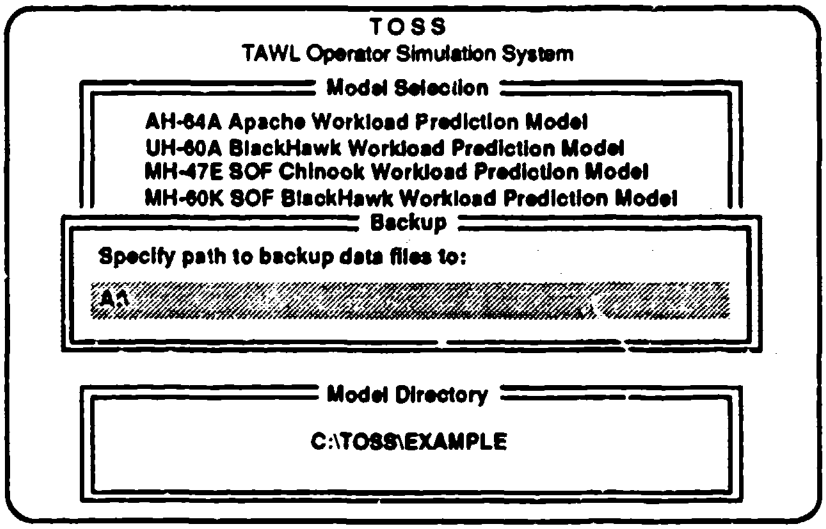
To delete an existing model and all its associated data files, highlight the model using the [↑] or [↓] key and press the [DELETE] key. This opens the Delete Model window.



To confirm that the selected model is to be deleted, press the [Y] key, followed by the [ENTER] key. To abort the request to delete the model, press the [ENTER] key.

MODEL BACKUP

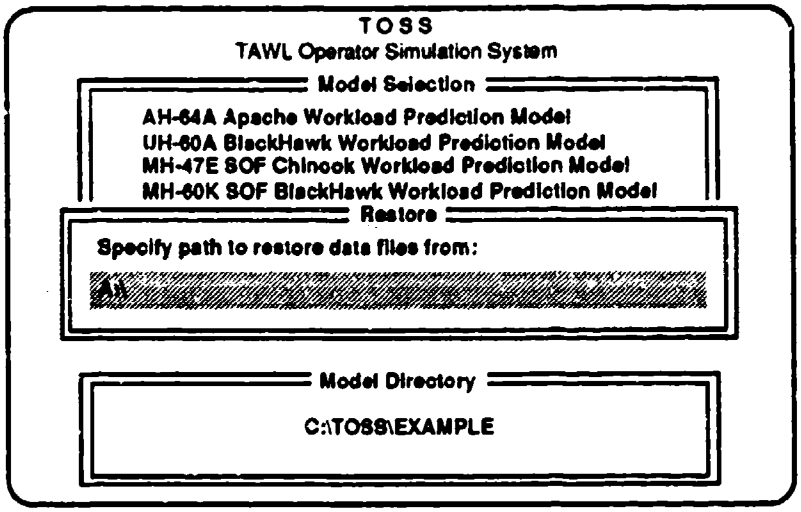
To make a backup copy of all a model's data files, highlight the model using the [↑] or [↓] key and press the [F11] or [ALT-B] key. This opens the Backup window.



Enter the DOS drive and path name of the directory where TOSS is to copy the files and press the [ENTER] key. To abort the request to backup the model and return to the Model Selection window, press the [ESC] key. If a valid directory has been entered, TOSS will copy the data files from the model directory to the specified directory and indicate that the model has been backed up successfully.

MODEL RESTORATION

CAUTION: Using the Model Restoration option overwrites current TOSS data. To restore a copy of all of a model's files from a backup, highlight the model using the [↑] or [↓] key and press the [F12] or [ALT-R] key. This opens the Restore window.



Enter the DOS drive and path name of the directory where TOSS is to find the backup files and press the [ENTER] key. To abort the request to restore the model and return to the Model Selection window, press the [ESC] key. If a valid directory has been entered and the model name of the selected model matches the model name in the specified directory, TOSS will copy the data files from the specified directory to the model directory and indicate that the model has been restored successfully.

If TOSS finds that the model names of the two directories do not match, it will open a Warning window displaying both model names and give you a chance to abort the restore command.

GLOSSARY

ACTIVE PERIOD	The span of time in which a random task or function is allowed to occur.
COMPONENT OVERLOAD	Each half-second period in which a workload component exceeds the overload threshold established in the model. The number of component overloads is computed separately for each crew-member defined in the model.
CONTINUOUS	Describes tasks whose magnitude or intensity of performance determine the magnitude of the resulting system response. The resulting state of the system in turn determines the magnitude or intensity of the subsequent performance of the task. Continuous tasks occur in closed-loop control systems. Mission requirements and conditions determine their start and end points. In TAWL, continuous is used in contrast to discrete.
DECISION RULES	A list of temporal sequencing information that describes the execution of tasks within a function or the execution of functions within a segment. A decision rule contains either a start time and finish time or a start time and duration.
DISCRETE	Tasks whose magnitude or intensity of performance does not determine the magnitude of the resulting system change. Discrete tasks occur in open-loop control systems. In TAWL, discrete is used in contrast to continuous.
FIXED	Describes tasks or functions that occur in a specified sequence rather than a random sequence.
FUNCTION	The collection of crewmembers' actions that are necessary to carry out a single logical activity. Functions are interruptible parts of a segment that may be present in different segments. Functions can be concurrent with or sequential to other functions in a segment. Functions are composed of tasks. Examples of functions include perform before-taxi check and check instrument panel.

FUNCTION CLASH PAIRS A pair of functions that cannot be performed concurrently. For example, in the attack helicopter, the copilot/gunner cannot perform the track targets automatically function and the track targets manually function at the same time.

INTERRUPT An interrupt occurs when the performance of one function is stopped temporarily in order to perform another one. For example, monitoring the external visual scene may be interrupted to check the instrument panel.

MISSION An operation of the system that is designed to accomplish a broad objective. Because there are several ways to accomplish that objective, a composite mission can be developed from several unique mission profiles (e.g., different routes, different targets). The composite mission contains as many operations as possible that are common to the various missions. A mission is composed of phases, segments, functions, and tasks. Examples of missions include seeking out and destroying enemy targets and transporting personnel and cargo from one point to another.

OVERLOAD A theoretical construct defined as the point at which an operator's attentional resources are so depleted by current task demands that performance on one or more of the tasks is degraded.

OVERLOAD CONDITION A period of time when one or more component overloads have occurred. An overload condition is counted each time a change in the tasks contributing to a component overload occurs. The number of overload conditions is computed separately for each crewmember defined in the model.

OVERLOAD DENSITY The percentage of time that an overload condition has occurred during a mission segment. The overload density is computed separately for each crewmember defined in the model.

OVERLOAD THRESHOLD A value established in the model (the default is 8) that determines the point at which a component overload occurs. TOSS maintains an overload threshold for each workload component. Each component overload threshold is defined for all crewmembers in the model.

PHASE A temporally discrete, uninterruptible, and nonrepeating part of a mission. A phase is a required, logical part of a mission that may be accomplished in several ways. Phases must be sequential to other phases (i.e., they do not occur concurrently) and must be contiguous. All portions of the mission are encompassed under one of the mission phases and every phase must be performed to accomplish the mission. Thus, the mission is composed of a sequence of phases placed end to end. Phases are composed of segments, functions, and tasks. Examples of phases include preflight, departure, en route, and target servicing.

RANDOM Describes two different aspects of tasks or functions: (a) they may occur at any time as opposed to a fixed time and (b) they may occur a variable number of times. In TAWL, random is used in contrast to fixed.

SEGMENT A temporally discrete, uninterruptible part of a phase. A segment represents a particular method of accomplishing a part of a phase. Segments must be sequential to other segments and must be contiguous. Several segments may represent a variety of methods used to complete a portion of the phase; thus, every segment within the phase may not need to be performed to complete the phase. Segments may be repeated in other phases. Segments are composed of functions and tasks. Examples of segments include contour flight and approach.

SUBSYSTEM A collection of mechanical, electrical, or computational equipment with which a crewmember must interact to perform a function. A subsystem is a component of a subsystem group. Examples of subsystems include brakes, hydraulics, and rotor.

SUBSYSTEM GROUP Two or more interacting, interrelated, or interdependent subsystems. Subsystems are maintained in TOSS as parts of subsystem groups. Examples of subsystem groups include navigation and flight control.

SUBSYSTEM OVERLOAD The number of times that a subsystem is associated with a component overload.

SYSTEM	The entire collection of equipment with which a crewmember must interact to accomplish a mission. Systems are composed of subsystem groups. Examples of systems include aircraft, tank, and automobile.
TASK	An uninterruptible crew activity that is essential to the successful completion of a function. The task is the basic element in the decomposition of a mission. Examples of tasks include adjust CRT intensity, set collective friction, and control altitude.
WORKLOAD	The total attentional demand required by all current tasks and responsibilities of an operator in a system. Attention is assumed to have several components. Workload is assessed for each component.
WORKLOAD COMPONENT	One of several attentional resources that can be temporarily depleted by task demands. Examples of workload components include cognitive, psychomotor, and sensory.
WORKLOAD COMPONENT SPECIFIER	A single character that further categorizes a workload component. For example, the psychomotor workload component might have two workload component specifiers, L for left hand and R for right hand.

APPENDIX A

BLANK WORKSHEETS

FUNCTION ANALYSIS WORKSHEET

FUNCTION

TOTAL TIME (Approximate) ? Seconds

TASKS		TASK #	SUBSYSTEM(S)	WORKLOAD COMPONENTS			SWITCH DESCRIPTION	DURATION (SECONDS) DISCRETE/ CONTINUOUS	
VERB	OBJECT			SENSORY	COGNITIVE	PSYCHOMOTOR			

FUNCTION SUMMARY WORKSHEET

FUNCTION

PILOT				COPILOT			
DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	CONTINUOUS (RANDOM)	DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	CONTINUOUS (RANDOM)

FUNCTION DECISION RULES WORKSHEET

FUNCTION

PILOT				COPILOT			
DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	CONTINUOUS (RANDOM)	DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	CONTINUOUS (RANDOM)

SEGMENT SUMMARY WORKSHEET

PHASE

SEGMENT

PILOT			COPILOT		
DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)

SEGMENT DECISION RULES WORKSHEET

PHASE **SEGMENT**

PILOT			COPILOT		
DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)	DISCRETE (FIXED)	DISCRETE (RANDOM)	CONTINUOUS (FIXED)

APPENDIX B

EXAMPLE WORKLOAD RATING SCALES

WORKLOAD COMPONENT SCALES

Scale Value	Verbal Descriptor
	Cognitive
1.0	Automatic (Simple Association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (Consider Single Aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (Consider Several Aspects)
7.0	Estimation, Calculation, Conversion
	Visual
1.0	Visually Register/Detect (Detect Occurrence of Image)
3.7	Visually Discriminate (Detect Visual Differences)
4.0	Visually Inspect/Check (Discrete Inspection/Static Condition)
5.0	Visually Locate/Align (Selective Orientation)
5.4	Visually Track/Follow (Maintain Orientation)
5.9	Visually Read (Symbol)
7.0	Visually Scan/Search/Monitor (Continuous/Serial Inspection, Multiple Conditions)
	Auditory
1.0	Detect/Register Sound (Detect Occurrence of Sound)
2.0	Orient to Sound (General Orientation/Attention)
4.2	Orient to Sound (Selective Orientation/Attention)
4.3	Verify Auditory Feedback (Detect Occurrence of Anticipated Sound)
4.9	Interpret Semantic Content (Speech)
6.6	Discriminate Sound Characteristics (Detect Auditory Differences)
7.0	Interpret Sound Patterns (Pulse Rates, etc.)
	Kinesthetic
1.0	Detect Discrete Activation of Switch (Toggle, Trigger, Button)
4.0	Detect Preset Position or Status of Object
4.8	Detect Discrete Adjustment of Switch (Discrete Rotary or Discrete Lever Position)
5.5	Detect Serial Movements (Keyboard Entries)
6.1	Detect Kinesthetic Cues Conflicting With Visual Cues
6.7	Detect Continuous Adjustment of Switches (Rotary Rheostat, Thumbwheel)
7.0	Detect Continuous Adjustment of Controls

WORKLOAD COMPONENT SCALES (continued)

Scale Value	Verbal Descriptor
	Psychomotor
1.0	Speech
2.2	Discrete Actuation (Button, Toggle, Trigger)
2.6	Continuous Adjustive (Flight Control, Sensor Control)
4.6	Manipulative
5.8	Discrete Adjustive (Rotary, Vertical Thumbwheel, Lever Position)
6.5	Symbolic Production (Writing)
7.0	Serial Discrete Manipulation (Keyboard Entries)
	Night Vision Goggles
1.0	Visually Register/Detect (Detect Occurrence of Image With NVG)
4.8	Visually Inspect/Check (Discrete Inspection/Static Condition) With NVG
5.0	Visually Discriminate (Detect Visual Differences) With NVG
5.6	Visually Locate/Align (Selective Orientation) With NVG
6.4	Visually Track/Follow (Maintain Orientation) With NVG
7.0	Visually Scan/Search/Monitor (Continuous/Serial Inspection, Multiple Conditions) With NVG

APPENDIX C

CONVERT VERSION 3 MODELS TO VERSION 4

INSTRUCTIONS FOR CONVERTING DATA TO TOSS VERSION 4.0

UPDATE4.EXE is a program to convert workload prediction models developed with the TOSS software prior to version 4.0 of the software. Several changes have been incorporated to the software in version 4.0.

If nonstandard file names have been used to store model data, those file names must be renamed to the default prior to conversion. The UPDATE4 program assumes the default file names are used to store model data.

Prior to using the UPDATE4 program, please make complete backups of all data files as well as previous versions of the TOSS software. If all else fails, this backup may be your only recourse!

To use the UPDATE4.EXE software to convert earlier models and function decision rule data to version 4.0 data, perform the following steps:

1. Execute the UPDATE4.EXE program by typing "UPDATE4" or answer yes to the CONVERT VERSION 3 MODELS TO VERSION 4? prompt during TOSS installation.

   To execute the UPDATE4.EXE program on a monochrome monitor, type "UPDATE4/m".

   This clears the computer screen and asks for a single letter specification of the disk drive containing the model.

2. Press the letter of the disk drive but do **not** press the [ENTER] key.

   This clears the screen and the program displays a graphical representation of the directory structure of the specified disk drive.

3. Use the arrow keys to highlight the directory that contains the old version of the model. Press the [ENTER] key.

4. Prior to the conversion of the model data, the program prompts for confirmation.

If confirmed, the program will convert MODEL.DAT to the new format and announce the success of the conversion.

5. Prior to the conversion of the function decision rules data, UPDATE4 prompts for confirmation.

   TOSS 4.0 no longer supports the interrupts at the task level. Thus, simulations of models developed under version 3.0 that utilize the interrupt feature of discrete random tasks will not run the same in version 4.0.

   If an interrupt occurs in any discrete random task, the program will beep and ask if you want to continue the conversion and ignore the interrupt. If you choose not to continue, the conversion will be aborted and will return you to the directory structure (Step 3). If you choose to continue, the program will convert BLDFUN.DAT to the new format and announce the success of the conversion.

6. Prior to the conversion of the segment decision rules data, UPDATE4 prompts for confirmation.

   If confirmed, the program will convert BLDSEG.DAT to the new format and announce the success of the conversion.

7. Prior to the conversion of the task data base files, UPDATE4 prompts for confirmation.

   If confirmed, the program will convert TASK.DAT, WORKLOAD.DAT, AND SS.DAT to the new format and announce the success of the conversion.

8. Prior to the conversion of the function names and segment names files, the program prompts for confirmation.

   The conversion is similar to Step 7.

9. UPDATE4 asks if there are any split functions in the function decision rules file.

   TOSS 4.0 no longer supports split functions. In the conversion of models from 3.0 to 4.0, UPDATE4 gives each part of a split function a unique function number and the same name as the original function.

   MAKE SURE STEP 8 HAS BEEN COMPLETED BEFORE PERFORMING THIS STEP!

If there are split functions, you are given the option of leaving the function numbers the same or renumbering them to be consecutive after the last non-splitting function number.

By renumbering the split function numbers, you will probably omit a lot of blank records in the function names file. Furthermore, if you choose to renumber, the program will also renumber the corresponding function number in your segment decision rules and function clash pairs files. The renumbering routine will also produce a text file named CHANGES.LST which lists the old split function number and its new function number.

If you are not sure if there are any split functions, perform the procedure anyway. These conversions only take a minute and ensures that everything is converted properly.

10. To convert another model, repeat Steps 3 through 9; otherwise, press the [ESC] key to exit the program.

APPENDIX D

SIMULATION LOGIC FLOW DIAGRAM

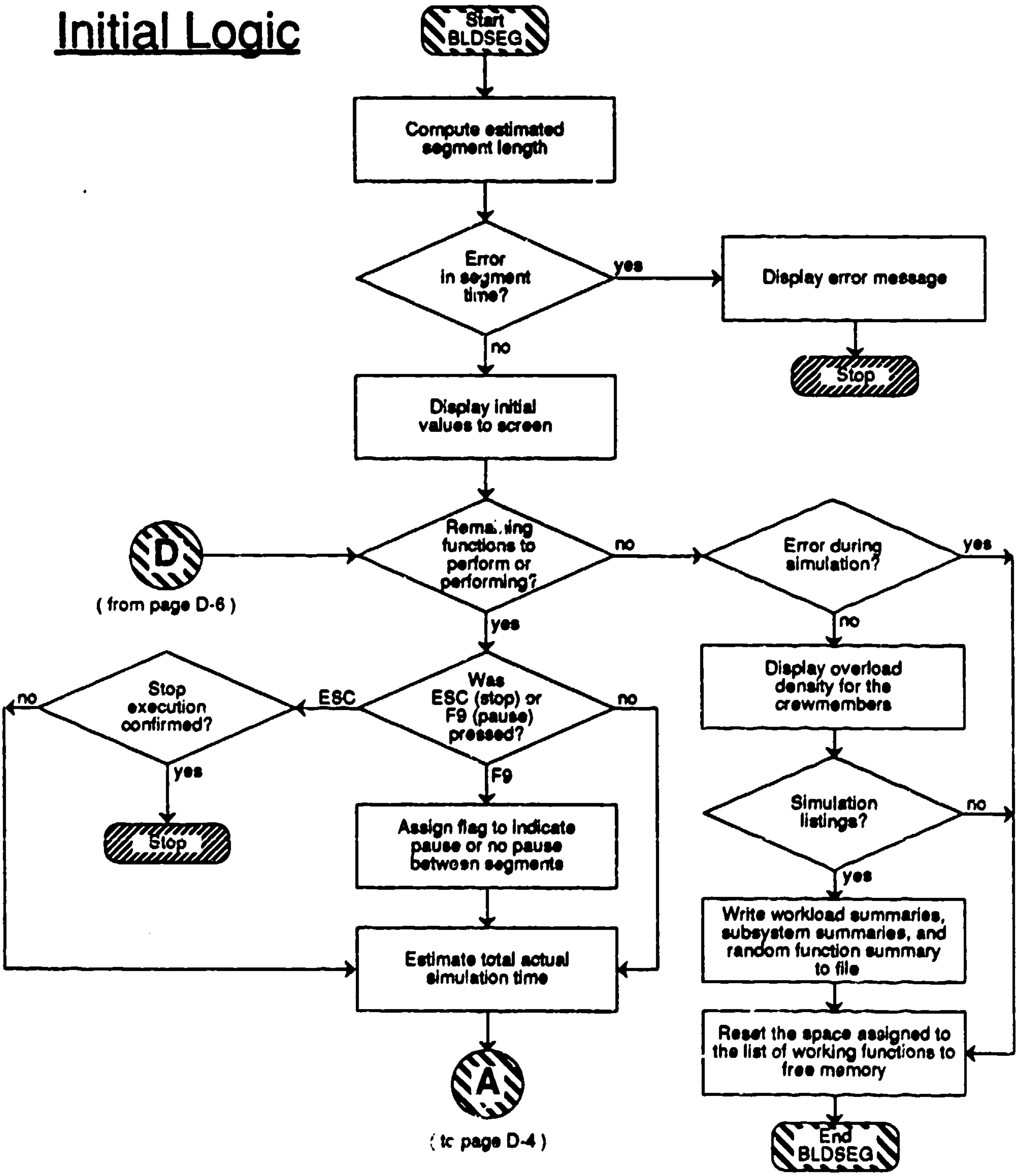
SIMULATION OVERVIEW

This appendix presents a detailed description of the processes and logic used by the computer during TOSS simulation. A brief summary of the simulation process is presented below and a flowchart of the process of simulation is presented on the following five pages. This appendix should provide sufficiently detailed information to understand the simulation process.

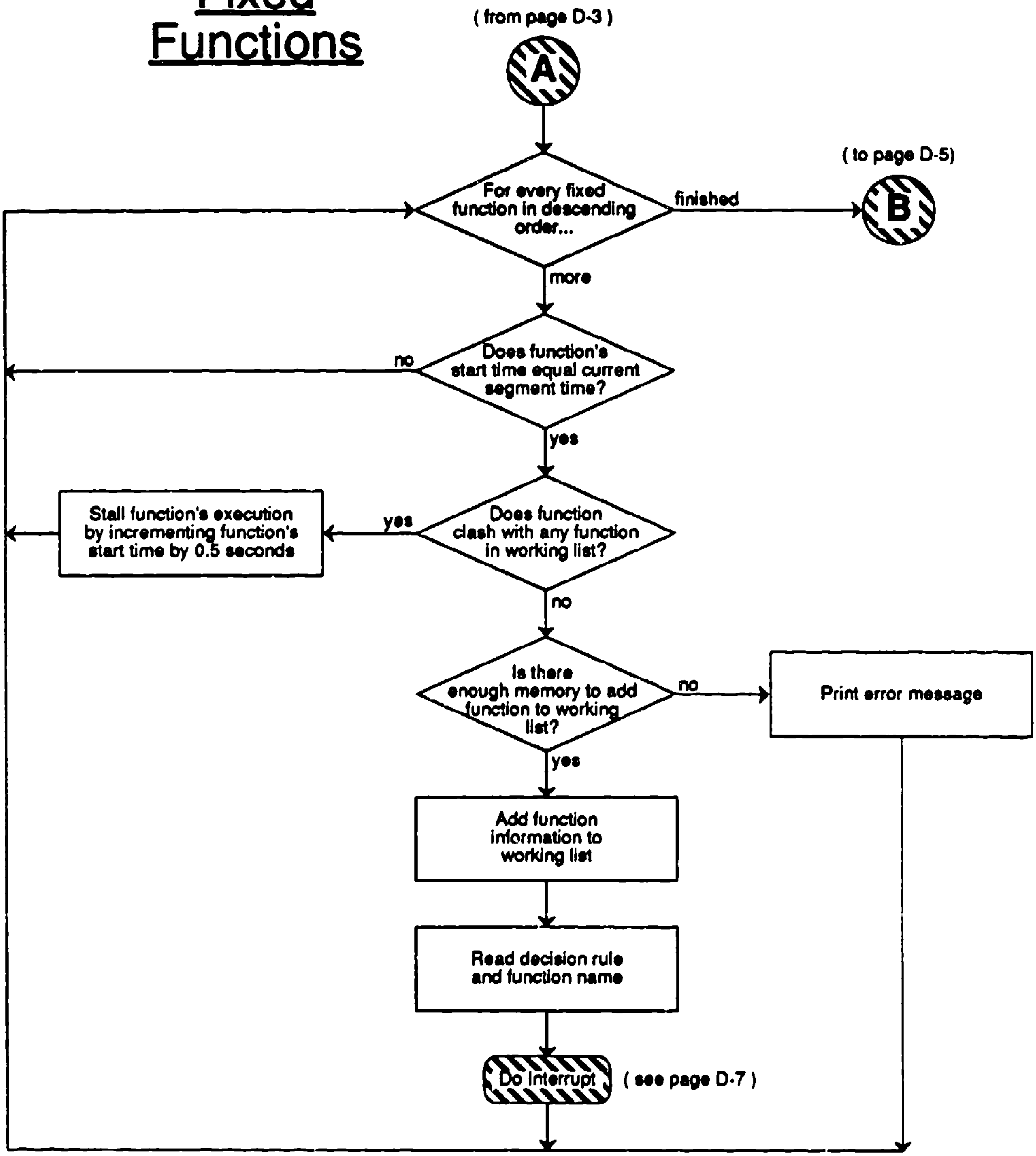
The simulation routine (BLDSEG) performs a loop until all the functions defined in the segment decision rule have been executed. Each pass through the loop represents one-half second in segment time. The simulation routine maintains a segment clock and separate function clocks that determine segment and function completion.

The simulation routine works by building a list of working functions and, for each function, a list of working tasks. Functions and tasks are added to the working list when they are ready to be performed. A working function is flagged if it is interrupted by another working function. A working function or task remains in the working list until it has been performed for its entire duration.

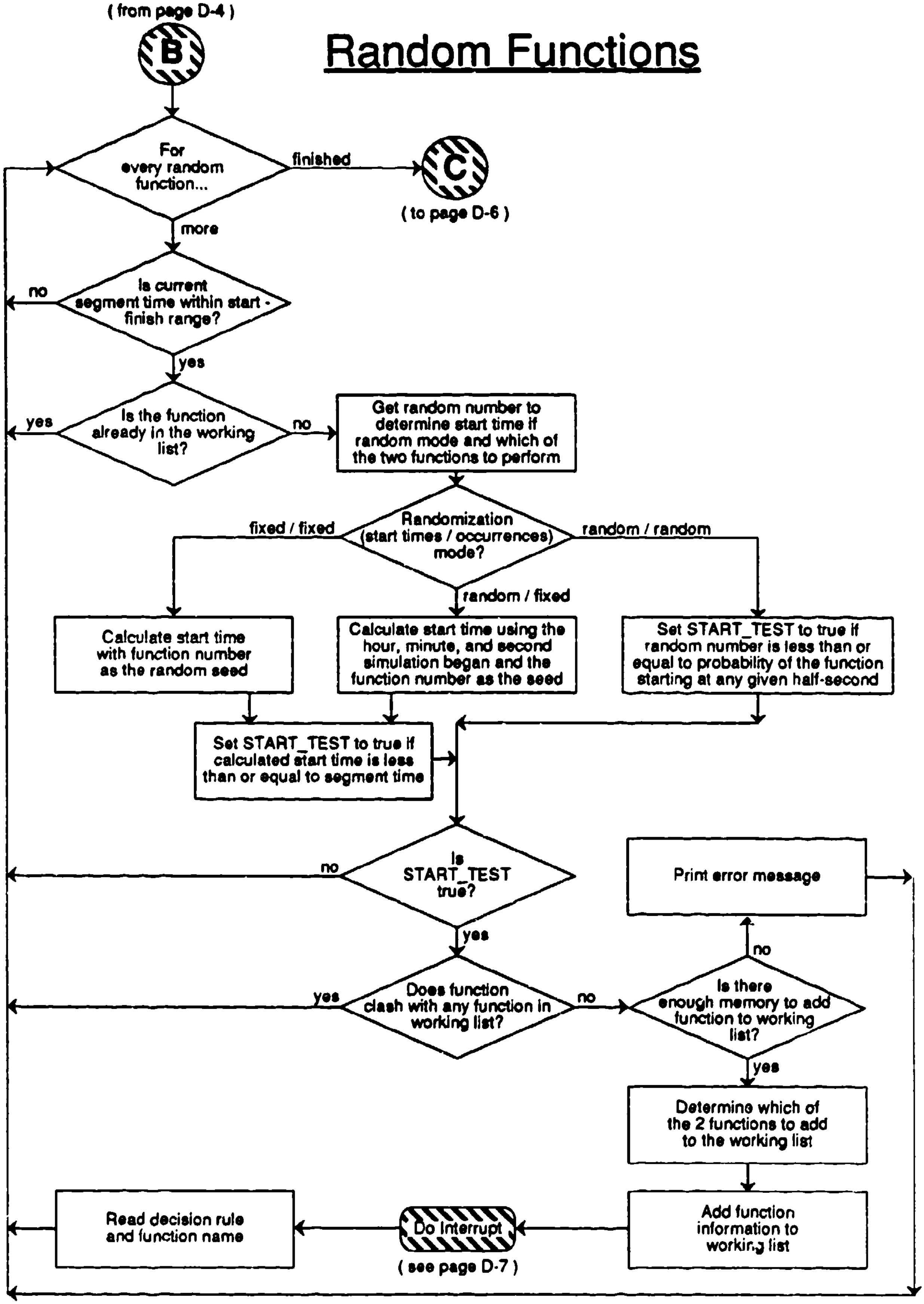
Initial Logic



Fixed Functions

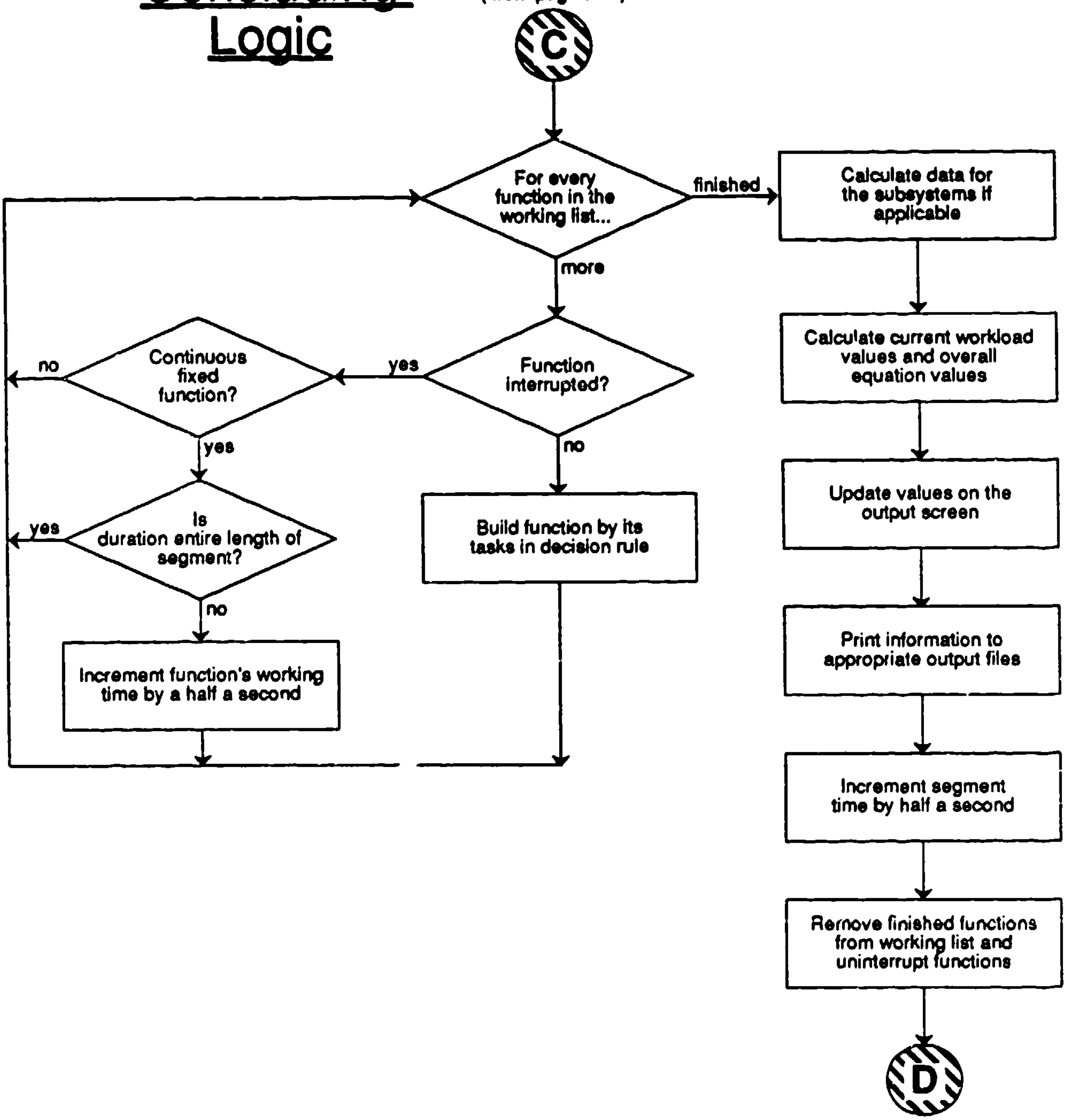


Random Functions



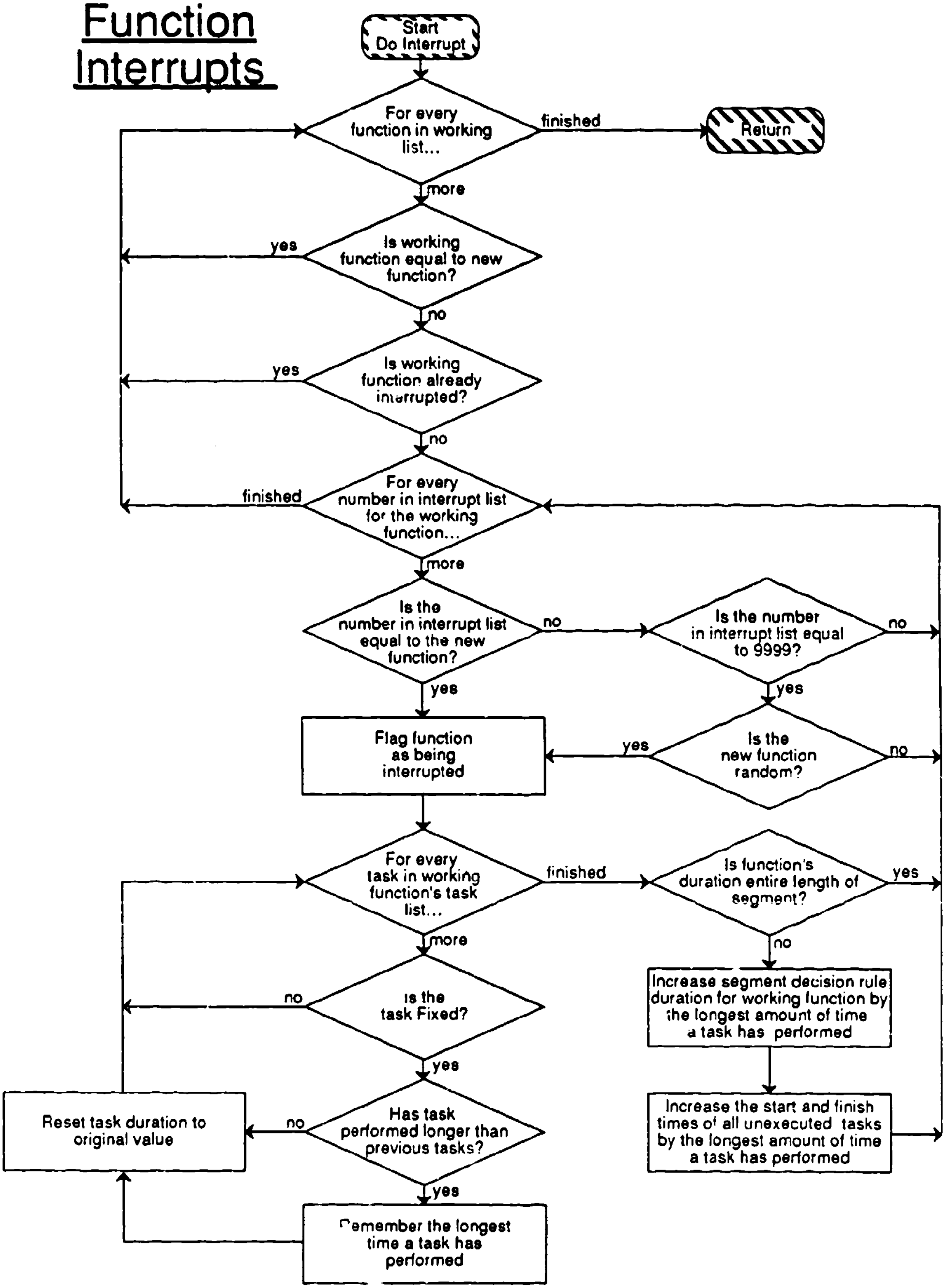
Concluding Logic

(from page D-5)



(to page D-3)

Function Interrupts



APPENDIX E

EXAMPLE OUTPUT OPTIONS

SCREEN OUTPUT

AH-64A Apache Workload Prediction Model

Segment Time
Predicted : 54.5
Actual : 54.5

Real Time
Predicted : 00:00:16
Actual : 00:16

Segment: 42 - Engagement, LOBL / Remote Designation

	PILOT Overload: 5 Density ~ 10.1%			GUNNER Overload: 3 Density = 2.8%		
	MEAN	PEAK	CO	MEAN	PEAK	CO
Aud	1.00	1.00	0	3.68	5.30	0
Kin	6.10	14.00	5	0.58	1.00	0
Vis	0.46	5.00	0	0.48	5.90	0
Cog	2.09	4.70	0	4.92	8.40	3
Psy	[illegible].27	5.20	0	0.70	2.20	0
OWL	11.92	28.20	11	10.37	18.50	0

Output Options: No Output File

NO PAUSE

Esc: Quit F9: Toggle Pause Feature
Segment completed . . . Press a key

AH-64A Apache Workload Prediction Model

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

November 20, 1990

Cum. Secs.		Aud	Kin	Vis	Cog	Psy	OWL	OL cond
	PILOT							
0.0	Function 76: Hover Unmasked							
	65 Control Attitude	0.00	7.00R	0.00	1.00	2.60R	10.60	
0.0	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	1.00	7.00	0.00	2.00	2.60	12.60	
	GUNNER							
0.0	Function 155: Transmit Message (Attack Coordination)							
	413 Transmit Message Alert	4.30	1.00R	0.00	5.30	1.00R	11.60	
0.0	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	5.30	1.00	0.00	6.30	1.00	13.60	
	PILOT							
1.5	Function 76: Hover Unmasked							
	160 Control Drift	0.00	7.00R	0.00	1.00	2.60R	10.60	
1.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	1.00	7.00	0.00	2.00	2.60	12.60	
	GUNNER							
1.5	Function 155: Transmit Message (Attack Coordination)							
	413 Transmit Message Alert	4.30	1.00R	0.00	5.30	1.00R	11.60	
1.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	5.30	1.00	0.00	6.30	1.00	13.60	

Segment Number: 42 November 20, 1990
Segment Title: Engagement, LOBL / Remote Designation

Cum. Secs.		Aud	Kin	Vis	Cog	Psy	OWL	OL cond
	PILOT							
2.5	Function 76: Hover Unmasked							
	160 Control Drift	0.00	7.00R	0.00	1.00	2.60R	10.60	
2.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	1.00	7.00	0.00	2.00	2.60	12.60	
	GUNNER							
2.5	Function 155: Transmit Message (Attack Coordination)							
	413 Transmit Message Alert	4.30	1.00R	0.00	5.30	1.00R	11.60	
2.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	5.30	1.00	0.00	6.30	1.00	13.60	
	PILOT							
3.5	Function 76: Hover Unmasked							
	36 Control Altitude	0.00	7.00L	0.00	1.00	2.60L	10.60	
3.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	1.00	7.00	0.00	2.00	2.60	12.60	
	GUNNER							
3.5	Function 155: Transmit Message (Attack Coordination)							
	680 Release Radio Transmitter Switch	0.00	1.00R	0.00	1.00	2.20R	4.20	
3.5	Function 83: Monitor Audio							
	66 Monitor Audio	1.00	0.00	0.00	1.00	0.00	2.00	
	Workload Totals:	1.00	1.00	0.00	2.00	2.20	6.20	

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

Cum. Secs.			Aud	Kin	Vis	Cog	Psy	OWL	OL cond
		PILOT							
24.5	Function	83: Monitor Audio							
	66 Monitor Audio		1.00	0.00	0.00	1.00	0.00	2.00	
24.5	Function	82: Mask Aircraft							
	Transition								
24.5	Function	115: Place Aircraft in Constraints							
	19 Stabilize Aircraft		0.00	7.00B	0.00	1.00	2.60B	10.60	
		Workload Totals:	1.00	7.00	0.00	2.00	2.60	12.60	
		GUNNER							
24.5	Function	83: Monitor Audio							
	66 Monitor Audio		1.00	0.00	0.00	1.00	0.00	2.00	
		Workload Totals:	1.00	0.00	0.00	1.00	0.00	2.00	
		PILOT							
25.0	Function	83: Monitor Audio							
	66 Monitor Audio		1.00	0.00	0.00	1.00	0.00	2.00	
25.0	Function	82: Mask Aircraft							
	395 Establish Masking Profile		0.00	7.00B	5.00B	1.00	2.60B	15.60	
25.0	Function	115: Place Aircraft in Constraints							
	19 Stabilize Aircraft		0.00	7.00B	0.00	1.00	2.60B	10.60	
		Workload Totals:	1.00	14.00	*5.00	3.00	5.20	*28.20	2
		Subsystems (PILOT): FC UC US VEX							
		GUNNER							
25.0	Function	83: Monitor Audio							
	66 Monitor Audio		1.00	0.00	0.00	1.00	0.00	2.00	
		Workload Totals:	1.00	0.00	0.00	1.00	0.00	2.00	

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

Workload Components

Aud	-	Auditory	-	8.00
Kin	-	Kinesthetic	-	8.00
Vis	-	Visual	-	8.00
Cog	-	Cognitive	-	8.00
Psy	-	Psychomotor	-	8.00

Workload Equation

Overall Workload: OWL = AUD+KIN+VIS+COG+PSY
Overload Minimum: 20.00

Randomization

Randomize when functions and tasks occur?	Yes
Randomize the number of times function and tasks occur?	Yes

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

PILOT

	Overload	Mean	Standard Deviation	Peak
Auditory	0	1.00	0.00	1.00
Kinesthetic	5	6.10	3.92	14.00
Visual	0	0.46	1.31	5.00
Cognitive	0	2.09	0.83	4.70
Psychomotor	0	2.27	1.46	5.20
Overall Workload	11	11.92	6.32	28.20

Segment Overall Workload = 11.92
Total Number of Overload Conditions = 5
Number of Seconds in an Overload Condition = 5.50
Number of Seconds in the Segment = 54.50

Overload Density = 10.1%

GUNNER

	Overload	Mean	Standard Deviation	Peak
Auditory	0	3.68	2.08	5.30
Kinesthetic	0	0.58	0.49	1.00
Visual	0	0.48	1.54	5.90
Cognitive	3	4.92	2.28	8.40
Psychomotor	0	0.70	0.69	2.20
Overall Workload	0	10.37	4.78	18.50

Segment Overall Workload = 10.37
Total Number of Overload Conditions = 3
Number of Seconds in an Overload Condition = 1.50
Number of Seconds in the Segment = 54.50

Overload Density = 2.8%

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

November 20, 1990

PILOT (P)

	OL	% Time	Aud Mean	Aud SI	Kin Mean	Kin SI	Vis Mean	Vis SI	Cog Mean	Cog SI	Psy Mean	Psy SI	OWL Mean	OWL SI
A - Armament Subsystem														
AFC Fire Control Computer	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGC Gun Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AL Laser	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AMC Missile Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ARC Rocket Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ASG Symbol Generator	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AW Weapons	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E - Engine Subsystem														
EF Fuel	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EE Engine	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EIN Engine Instruments	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EO Engine Oil	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EI Ignition	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F - Flight Control Subsystem														
FA Air Frame	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FB Brakes	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FC Flight Control	5	83.5	0.0	0.0	7.8	655.0	0.4	31.2	1.1	93.6	2.9	243.3	12.3	1023.1
FI Flight Instruments	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FG Gear	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FH Hydraulics	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR Rotor	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FT Transmission	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N - Navigation Subsystem														
NM Maps	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC Navigation Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ND Navigation Display	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S - Safety Subsystem														
SG Ground Security	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S Safety	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U - Utility Subsystem														
UAD Advisory	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UAI Anti-Ice	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UAP APU	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UC Communications	5	100.0	1.0	100.0	0.0	0.0	0.0	0.0	1.0	100.0	0.0	0.0	2.0	200.0
UEL Electrical	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UEN Environmental	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UF Flight Forms	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UL Lighting	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US Survivability	5	100.0	1.0	100.0	0.0	0.0	0.1	5.5	1.2	120.4	0.0	0.0	2.3	225.9
UV Video	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V - Visual Subsystem														
VEX External Visual Field	2	11.0	0.0	0.0	5.8	64.2	3.7	40.4	1.0	11.0	2.2	23.9	12.7	139.4
VSC Sensor Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VSD Sensor Display	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VVD Visual Display	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Segment Number: 42 November 20, 1990
Segment Title: Engagement, LOBL / Remote Designation

GUNNER (G)

	OL	% Time	Aud Mean	Aud SI	Kin Mean	Kin SI	Vis Mean	Vis SI	Cog Mean	Cog SI	Psy Mean	Psy SI	OWL Mean	OWL SI
A - Armament Subsystem														
AFC Fire Control Computer	3	6.4	0.0	0.0	0.0	0.0	5.9	37.9	4.2	26.7	0.0	0.0	10.1	64.6
AGC Gun Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AL Laser	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AMC Missile Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ARC Rocket Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ASG Symbol Generator	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AW Weapons	3	6.4	0.0	0.0	1.0	6.4	0.0	0.0	3.3	21.3	2.2	14.1	6.5	41.8
E - Engine Subsystem														
EF Fuel	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EE Engine	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EIN Engine Instruments	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EO Engine Oil	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EI Ignition	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F - Flight Control Subsystem														
FA Air Frame	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FB Brakes	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FC Flight Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FI Flight Instruments	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FG Gear	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FH Hydraulics	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR Rotor	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FT Transmission	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N - Navigation Subsystem														
NM Maps	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC Navigation Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ND Navigation Display	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S - Safety Subsystem														
SG Ground Security	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S Safety	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U - Utility Subsystem														
UAD Advisory	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UAI Anti-Ice	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UAP APU	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UC Communications	3	100.0	3.7	368.3	0.5	51.4	0.0	0.0	4.3	434.3	0.6	55.8	9.1	909.7
UEL Electrical	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UEN Environmental	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UF Flight Forms	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UL Lighting	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US Survivability	3	100.0	1.0	100.0	0.0	0.0	0.0	0.0	1.0	100.0	0.0	0.0	2.0	200.0
UV Video	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V - Visual Subsystem														
VEX External Visual Field	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VSC Sensor Control	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VSD Sensor Display	3	5.5	0.0	0.0	0.0	0.0	4.8	26.4	3.7	20.4	0.0	0.0	8.5	46.8
VVD Visual Display	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Segment Number: 7
Segment Title: Contour Flight (Threat) (NVG)

Function 25: times = 15, ceiling = 23, performed = 9, remaining = 14

Function 3: times = 5, ceiling = 8, performed = 5, remaining = 3

Function 18: times = 5, ceiling = 8, performed = 5, remaining = 3

Function 55: times = 1. ceiling = 2, performed = 0, remaining = 2

Function 63: times = 3, ceiling = 5, performed = 1, remaining = 4

Function 58: times = 10, ceiling = 15, performed = 6, remaining = 9

Function 69: times = 20, ceiling = 30, performed = 21, remaining = 9

NUMERICAL DATA FILE

0.0	1.00	7.00	0.00	2.00	2.60	12.60
0.5	1.00	7.00	0.00	2.00	2.60	12.60
1.0	1.00	7.00	0.00	2.00	2.60	12.60
1.5	1.00	7.00	0.00	2.00	2.60	12.60
2.0	1.00	7.00	0.00	2.00	2.60	12.60
2.5	1.00	7.00	0.00	2.00	2.60	12.60
3.0	1.00	7.00	0.00	2.00	2.60	12.60
3.5	1.00	7.00	0.00	2.00	2.60	12.60
4.0	1.00	7.00	0.00	2.00	2.60	12.60
4.5	1.00	7.00	0.00	2.00	2.60	12.60
5.0	1.00	7.00	0.00	2.00	2.60	12.60
5.5	1.00	7.00	0.00	2.00	2.60	12.60
6.0	1.00	0.00	1.00	4.70	0.00	6.70
6.5	1.00	0.00	1.00	4.70	0.00	6.70
7.0	1.00	0.00	1.00	4.70	0.00	6.70
7.5	1.00	0.00	1.00	4.70	0.00	6.70
8.0	1.00	0.00	1.00	4.70	0.00	6.70
8.5	1.00	0.00	1.00	4.70	0.00	6.70
9.0	1.00	0.00	0.00	1.00	0.00	2.00
9.5	1.00	7.00	0.00	2.00	2.60	12.60
10.0	1.00	7.00	0.00	2.00	2.60	12.60
10.5	1.00	7.00	0.00	2.00	2.60	12.60
11.0	1.00	7.00	0.00	2.00	2.60	12.60
11.5	1.00	7.00	0.00	2.00	2.60	12.60
12.0	1.00	7.00	0.00	2.00	2.60	12.60
12.5	1.00	7.00	0.00	2.00	2.60	12.60
13.0	1.00	7.00	0.00	2.00	2.60	12.60
13.5	1.00	7.00	0.00	2.00	2.60	12.60
14.0	1.00	7.00	0.00	2.00	2.60	12.60
14.5	1.00	7.00	0.00	2.00	2.60	12.60
15.0	1.00	7.00	0.00	2.00	2.60	12.60
15.5	1.00	7.00	0.00	2.00	2.60	12.60
16.0	1.00	7.00	0.00	2.00	2.60	12.60
16.5	1.00	7.00	0.00	2.00	2.60	12.60
17.0	1.00	7.00	0.00	2.00	2.60	12.60
17.5	1.00	7.00	0.00	2.00	2.60	12.60
18.0	1.00	7.00	0.00	2.00	2.60	12.60
18.5	1.00	7.00	0.00	2.00	2.60	12.60
19.0	1.00	7.00	0.00	2.00	2.60	12.60
19.5	1.00	7.00	0.00	2.00	2.60	12.60
20.0	1.00	7.00	0.00	2.00	2.60	12.60
20.5	1.00	7.00	0.00	2.00	2.60	12.60
21.0	1.00	7.00	5.00	3.00	2.60	18.60
21.5	1.00	7.00	5.00	3.00	2.60	18.60
22.0	1.00	7.00	0.00	2.00	2.60	12.60
22.5	1.00	14.00	1.00	3.00	5.20	24.20
23.0	1.00	14.00	1.00	3.00	5.20	24.20
23.5	1.00	14.00	1.00	3.00	5.20	24.20
24.0	1.00	7.00	1.00	2.00	2.60	13.60
24.5	1.00	7.00	0.00	2.00	2.60	12.60
25.0	1.00	14.00	5.00	3.00	5.20	28.20
25.5	1.00	14.00	5.00	3.00	5.20	28.20
26.0	1.00	14.00	5.00	3.00	5.20	28.20
26.5	1.00	14.00	5.00	3.00	5.20	28.20
27.0	1.00	14.00	5.00	3.00	5.20	28.20
27.5	1.00	7.00	5.00	2.00	2.60	17.60
28.0	1.00	7.00	0.00	2.00	2.60	12.60
28.5	1.00	7.00	0.00	2.00	2.60	12.60

TASK LISTING

Segment Number: 42   November 20, 1990
Segment Title: Engagement, LOBL / Remote Designation

```
0.0
  PILOT    (P)    65: Control Attitude
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
0.5
  PILOT    (P)   305: Control Heading
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
1.0
  PILOT    (P)   305: Control Heading
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
1.5
  PILOT    (P)   160: Control Drift
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
2.0
  PILOT    (P)    65: Control Attitude
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
2.5
  PILOT    (P)   160: Control Drift
                  66: Monitor Audio
  GUNNER   (G)   413: Transmit Message Alert
                  66: Monitor Audio
3.0
  PILOT    (P)   160: Control Drift
                  66: Monitor Audio
  GUNNER   (G)    66: Monitor Audio
3.5
  PILOT    (P)    36: Control Altitude
                  66: Monitor Audio
  GUNNER   (G)   680: Release Radio Transmitter Switch
                  66: Monitor Audio
4.0
  PILOT    (P)    65: Control Attitude
                  66: Monitor Audio
  GUNNER   (G)    66: Monitor Audio
4.5
  PILOT    (P)   305: Control Heading
                  66: Monitor Audio
  GUNNER   (G)     2: Note Acknowlegment
                  66: Monitor Audio
5.0
  PILOT    (P)    65: Control Attitude
                  66: Monitor Audio
  GUNNER   (G)     2: Note Acknowlegment
                  66: Monitor Audio
```

APPENDIX F

EXAMPLE OUTPUT OF MODEL DATA BASE

1. TASK DATA BASE

AH-64A Apache Workload Prediction Model
File: C:\TOSS\AH-64\TASK.DAT, SS.DAT and WORKLOAD.DAT

	Task	Subsystems			Aud	Kin	Vis	Cog	Psy
1.	Set Accelerometer	FI			0.00	0.00	7.00I	1.20	2.20R
2.	Note Acknowlegment	UC			4.30	0.00	0.0C	5.30	0.00
3.	Transmit Acknowledgment	UC			4.30	1.00R	0.00	5.30	1.00R
4.	Check ACM Switch	VSC			0.00	0.00	4.00I	3.70	0.00
5.	Set ACM Switch	VSC			0.00	0.00	7.00I	1.20	2.20L
6.	Check ACQ SEL Switch (G)	VSC			0.00	0.00	4.00I	3.70	0.00
7.	Set ACQ SEL Switch (G)	VSC			0.00	0.00	7.00I	1.20	5.80L
8.	Check ACQ SEL Switch (P)	VSC			0.00	0.00	4.00I	3.70	0.00
9.	Set ACQ SEL Switch (P)	VSC			0.00	0.00	7.00I	1.20	2.20L
10.	Check ADF Control Switch	NC			0.00	0.00	4.00I	3.70	0.00
11.	Set ADF Control Switch	NC			0.00	0.00	7.00I	1.20	5.80R
12.	Check ADF Operation	NC			6.60	0.00	7.00I	3.70	5.80R
13.	Check ADSS Switch	AFC			0.00	0.00	4.00I	3.70	0.00
14.	Set ADSS Switch	AFC			0.00	0.00	7.00I	1.20	2.20L
15.	Check Aft Gravity Fuel Cap	EF			0.00	0.00	4.00E	3.70	0.00
16.	Check Aft Stowage Bay	FA			0.00	0.00	4.00E	3.70	0.00
17.	Check Aft Tailboom	FA			0.00	0.00	4.00E	3.70	0.00
18.	Check Air Data Sensor	AFC			0.00	0.00	4.00E	3.70	0.00
19.	Stabilize Aircraft	FC			0.00	7.00B	0.00	1.00	2.60B
20.	Maneuver Aircraft Across Landmark	FC	VEX		0.00	7.00R	5.00E	6.80	2.60R
21.	Check Aircraft Covers	SG			0.00	0.00	4.00E	3.70	0.00
22.	Adjust Heading (Hover)	FC			0.00	7.00F	0.00	1.00	2.60F
23.	Position Aircraft into Wind	FC	VEX		0.00	7.00F	5.00E	1.00	2.60F
24.	Check Aircraft Location (G)	ND	NM	VSD	0.00	0.00	5.90I	6.80	2.60R
25.	Verify Aircraft Location (G)	VEX			0.00	0.00	5.90E	6.80	2.60R
26.	Check Aircraft Location (P)	VEX			0.00	0.00	7.00E	4.60	0.00
27.	Transmit Aircraft Status	UC			4.30	1.00R	0.00	5.30	1.00R
28.	Survey Aircraft Surroundings (G)	VSD			0.00	0.00	7.00I	4.60	2.60R
29.	Survey Aircraft Surroundings (P)	VEX			0.00	0.00	7.00E	4.60	0.00
30.	Position Aircraft Toward Target	FC			0.00	7.00F	5.00E	1.00	2.50F
31.	Control Airspeed	FC			0.00	7.00B	1.00E	1.00	2.60B
32.	Check Airspeed Indicator	FI			0.00	0.00	4.00I	3.70	0.00
33.	Change Airspeed Quickly	FC	VEX		0.C0	7.00B	7.00E	1.00	2.60B
34.	Set Altimeter	FI			0.00	0.00	7.00I	1.20	5.80R
35.	Adjust Altitude	FC	VEX		0.00	7.0CL	1.00E	1.00	2.60L
36.	Control Altitude	FC			0.00	7.00L	0.00	1.00	2.60L
37.	Change Altitude	FC			0.00	7.00L	0.00	1.00	2.60L
38.	Change Altitude Sharply	FC	VEX		0.00	7.00B	7.00E	1.00	2.60B
39.	Check Ammunition Bay Access	FA			0.00	0.00	4.00E	3.70	0.00
40.	Set AN / APR 39	US			0.00	0.00	7.00I	1.20	5.80R
41.	Check AND Display (Laser Code)	AFC			0.00	0.00	5.90I	5.30	0.00
42.	Check AND Display (LMC)	AFC			0.00	0.00	5.90I	5.30	0.00
43.	Check AND Display (Missile)	AFC			0.00	0.00	5.90I	5.30	0.00
44.	Check AND Display (Offset)	AFC			0.00	0.00	5.90I	5.30	0.00
45.	Check AND Display (Polarity)	AFC			0.00	0.00	5.90I	5.30	0.00
46.	Check AND Display (Priority)	AFC			0.00	0.00	5.90I	5.30	0.00
47.	Check AND Display (Search)	AFC			0.00	0.00	5.90I	5.30	0.00
48.	Check AND Display (Tracking)	AFC			0.00	0.00	5.90I	5.30	0.00
49.	Check Anticollision Light Switch	UL			0.00	0.00	4.00I	3.70	0.00
50.	Check Anti-ice Control Switch	UAI			0.00	0.00	4.00I	3.70	0.00

2. FUNCTION NAMES

1. Acquire Target (DTV)
2. Acquire Target (Laser Spot Tracker, Automatic)
3. Acquire Target (Laser Spot Tracker, Manual)
4. Acquire Target (DVO)
5. EMPTY
6. EMPTY
7. Acquire Target (FLIR)
8. EMPTY
9. EMPTY
10. Activate Ignition
11. Adjust IHADSS Boresight (Gunner)
12. Adjust IHADSS Boresight (Pilot)
13. Adjust Outfront Boresight
14. Arrange Cockpit (Gunner)
15. Arrange Cockpit (Pilot)
16. Change Battle Position
17. Check Aircraft Systems (Gunner)
18. Check Aircraft Systems (Pilot)
19. Check Area Security (Sensor Search)
20. Check Area Security (Visual Search)
21. Check Armament Subsystems (Gunner)
22. Check Armament Subsystems (Pilot)
23. Check Cockpit Conditions (Gunner)
24. Check Cockpit Conditions (Pilot)
25. Check Collective Switches (Gunner)
26. Check Collective Switches (Pilot)
27. Check Engine 1 ECU Lockout System
28. Check Engine 2 ECU Lockout System
29. Check Engine Chop Circuit
30. Check Fuel Sample
31. Check Helmet (Gunner)
32. Check Helmet (Pilot)
33. Check Instrument Panel (Gunner)
34. Check Instrument Panel (Pilot)
35. Check Left Control Console (Gunner)
36. Check Left Control Console (Pilot)
37. Check Left Side - Fuselage and Nose
38. Check Left Side - Mast
39. Check Left Side - Rear Fuselage
40. Check Left Side - Wing
41. Check Overhead Panel
42. Check Right Control Console (Gunner)
43. Check Right Control Console (Pilot)
44. Check Right Side - Mast
45. Check Right Side - Rear Fuselage
46. Check Right Side - Under Fuselage
47. Check Right Side - Wing
48. Check Security Devices
49. Complete TAMMS Forms
50. Compute Fuel Burn Rate
51. Conduct Postflight Walk Around
52. Consolidate Forces
53. Coordinate Mission

3. Function Decision Rules

AH-64A Apache Workload Prediction Model
File: C:\TOSS\AH-64\BLDFUN.DAT

Page 1
November 30, 1990

Function 80: Land Aircraft

Discrete Fixed Tasks

Entry #	Task #	Task Name	Crewmember	Start	Duration
1	593	Perform Touchdown	PILOT (P)	10.5	3.0

Discrete Random Tasks

Entry #	Task #	Task Name	Crewmember	Start	Duration	Finish	Times
1	690	Check Obstacle Clearance	GUNNER (G)	0.0	1.0	10.0	5

Continuous Random Tasks

Start : 0.0
Finish: 10.0
Crewmember: PILOT (P)

Entry #	Task #	Task Name	Duration
1	65	Control Attitude	0.5
2	160	Control Drift	0.5
3	305	Control Heading	0.5
4	439	Maintain Obstacle Clearance	0.5
5	466	Adjust Power	0.5

4. Segment Names

1. Flight Planning
2. Exterior Cockpit Check
3. Preflight Walk Around
4. Interior Cockpit Check
5. Starting APU
6. After Starting APU
7. Taxi
8. Takeoff (Contour)
9. Contour Flight
10. NOE Flight
11. Approach (Contour)
12. Approach (NOE)
13. Landing
14. Holding Area Operations (Inbound)
15. Holding Area Operations (Outbound)
16. Takeoff (NOE)
17. Establishment of Battle Position
18. Deployment in Battle Area
19. Target Handover (Laser Spot Tracker)
20. Target Handover, Grid (Missile)
21. Target Handover, Grid (Gun, Pilot)
22. Target Handover, Grid (Gun, Gunner)
23. Target Handover, Grid (Gun, Gunner, Laser Range)
24. Target Handover, Grid (FFAR, Pilot)
25. Target Handover, Grid (FFAR, Cooperative)
26. Acquisition (DTV)
27. Acquisition (DTV, Laser Spot Tracker, Manual)
28. Acquisition (DTV, Laser Spot Tracker, Automatic)
29. Acquisition (DVO)
30. Acquisition (DVO, Laser Spot Tracker, Manual)
31. Acquisition (DVO, Laser Spot Tracker, Automatic)
32. Acquisition (FLIR)
33. Acquisition (FLIR, Laser Spot Tracker, Manual)
34. Acquisition (FLIR, Laser Spot Tracker, Automatic)
35. Engagement, LOAL / Autonomous (Track Target, Manual)
36. Engagement, LOAL / Autonomous (Track Target, Image Autotracker)
37. Engagement, LOAL / Autonomous (Track Target, Image Autotracker Off
38. Engagement, LOAL / Remote Designation
39. Engagement, LOBL / Autonomous (Track Target, Manual)
40. Engagement, LOBL / Autonomous (Track Target, Image Autotracker)
41. Engagement, LOBL / Autonomous (Track Target, Image Autotracker Off
42. Engagement, LOBL / Remote Designation
43. Engagement, Gun (Pilot, Normal)
44. Engagement, Gun (Gunner, Normal)
45. Engagement, Gun (Gunner, Normal, TADS Laser Range)
46. Engagement, FFAR (Pilot, Normal)
47. Engagement, FFAR (Cooperative, Normal, TADS Laser Range)
48. Engagement, LOAL / Rapid Fire
49. Engagement, LOAL / Ripple Fire
50. FARP Procedures
51. Engine Shutdown
52. Before Leaving Aircraft

5. SEGMENT DECISION RULES

Segment 16: Takeoff (NOE)

Discrete Fixed Functions

Function #	Function Name	Start	Duration	Interrupt
161	Perform Before Hover Check	0.0	182.5	78 79 84
162	Establish Hover	-161.0	8.0	18 84
95	Perform Before Takeoff Check (Gunner)	-105.0	20.0	17 78 79
103	Perform External Communication (Gunner)	-95.0	28.0	
96	Perform Before Takeoff Check (Pilot)	-105.0	48.5	18 78 79 84
60	Establish Climb	-96.0	8.0	18 84
61	Establish Level of Flight	-164.0	6.0	18 84
169	Check Fuel Consumption Parameters	-60.0	7.0	17

Continuous Fixed Functions

Function #	Function Name	Start	Duration	Interrupt
83	Monitor Audio	0.0	-0.5	
105	Perform Hover	-162.0	120.0	18 84
163	Monitor Flight Controls	-105.0	48.5	18 84
164	Adjust Climb Parameters	-60.0	30.0	18 84
168	Adjust Level of Flight Parameters	-61.0	60.0	18 84 167

Discrete Random Functions

Function #	Function Name	Duration	Start	Finish	Times	Interrupt
78	Initiate Cockpit Communication (Coord-Gu	7.0	0.0	-0.5	4	
79	Initiate Cockpit Communication (Coord-Pi	7.0				
84	Monitor Threat (Pilot)	3.5	0.0	-0.5	2	
18	Check Aircraft Systems (Pilot)	7.5	-161.0	-0.5	1	
84	Monitor Threat (Pilot)	3.5	0.0	-0.5	2	
17	Check Aircraft Systems (Gunner)	11.0	0.0	-0.5	1	
165	Check Climb Parameters	1.0	-60.0	30.0	4	
167	Check Level of Flight Parameters	1.0	-61.0	60.0	8	

Relevant Function Clash Pairs

84: 18
18: 84
84: 18

6. Function Clash Pairs


```
Function #  13:  78, 79
Function #  17:  50, 78, 79, 103, 122, 161, 88, 158, 157, 169, 84
Function #  18:  84, 104, 123, 126, 78, 79, 165, 167, 170, 172, 171
Function #  50:  17, 122, 78, 79
Function #  52:  78, 79
Function #  53:  78, 79
Function #  78:  17, 84, 104, 123, 126, 122, 161, 158, 88, 103, 50, 157, 18, 79, 13, 169, 53, 52
Function #  79:  17, 84, 104, 123, 126, 122, 161, 158, 88, 103, 50, 157, 18, 78, 13, 169, 53, 52
Function #  84:  18, 78, 79, 104, 123, 126, 165, 167, 170, 172, 17
Function #  88:  78, 79, 17, 122
Function # 103:  17, 122, 123, 78, 79
Function # 104:  18, 78, 79, 84, 123
Function # 122:  17, 50, 78, 79, 103, 158, 123, 161, 88, 157
Function # 123:  18, 78, 79, 84, 126, 103, 104, 122
Function # 126:  18, 78, 79, 84, 123, 170
Function # 157:  17, 78, 79, 122
Function # 158:  122, 79, 78, 17
Function # 161:  78, 79, 17, 122
Function # 165:  18, 84
Function # 167:  18, 84
Function # 169:  17, 78, 79
Function # 170:  18, 84, 126
Function # 171:  18
Function # 172:  18, 84
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7. TASK CROSS-REFERENCE

1	Set Accelerometer	34, 51
2	Note Acknowlegment	21, 22, 86, 129, 130, 135, 155
3	Transmit Acknowledgment	52, 53, 90, 91, 95, 96, 103, 104, 122, 123, 124
4	Check ACM Switch	34, 136, 139
5	Set ACM Switch	108, 111, 129, 130, 135, 136
6	Check ACQ SEL Switch (G)	33, 58, 135, 136, 143
7	Set ACQ SEL Switch (G)	58, 71, 72, 131
8	Check ACQ SEL Switch (P)	34, 135, 136
9	Set ACQ SEL Switch (P)	36, 96, 130
10	Check ADF Control Switch	40, 43, 47
11	Set ADF Control Switch	40, 47, 87, 110
12	Check ADF Operation	40, 47, 87
13	Check ADSS Switch	35, 40, 47
14	Set ADSS Switch	40, 47, 86, 129
15	Check Aft Gravity Fuel Cap	36, 45, 148
16	Check Aft Stowage Bay	39, 110, 145, 148
17	Check Aft Tailboom	39, 45, 88
18	Check Air Data Sensor	38, 46
19	Stabilize Aircraft	25, 26, 115, 156, 160
20	Maneuver Aircraft Across Landmark	23, 24
21	Check Aircraft Covers	14, 15, 48, 128
22	Adjust Heading (Hover)	92, 115
23	Position Aircraft into Wind	97, 111, 132, 142
24	Check Aircraft Location (G)	13, 19, 62, 111, 133, 134, 143, 144
25	Verify Aircraft Location (G)	93, 94, 145, 157, 158
26	Check Aircraft Location (P)	1, 2, 3, 4, 5, 6, 7, 8, 9, 19, 33, 62, 111, 142
27	Transmit Aircraft Status	11, 52, 106, 129, 135, 137, 138
28	Survey Aircraft Surroundings (G)	34, 62
29	Survey Aircraft Surroundings (P)	12, 62, 108, 130
30	Position Aircraft Toward Target	118
31	Control Airspeed	16, 46, 73, 74, 164, 168, 171
32	Check Airspeed Indicator	33, 34, 58, 70, 111, 131, 143
33	Change Airspeed Quickly	29, 126
34	Set Altimeter	33, 34, 39, 45
35	Adjust Altitude	73, 74, 87
36	Control Altitude	16, 34, 75, 76, 105, 156, 168
37	Change Altitude	87, 145, 156
38	Change Altitude Sharply	126, 131
39	Check Ammunition Bay Access	39, 47, 131
40	Set AN / APR 39	87, 110, 127, 148, 149
41	Check AND Display (Laser Code)	37, 117
42	Check AND Display (LMC)	37, 46, 154
43	Check AND Display (Missile)	35, 95
44	Check AND Display (Offset)	22, 36, 153
45	Check AND Display (Polarity)	44, 153
46	Check AND Display (Priority)	2, 5, 8, 70, 140, 141, 159
47	Check AND Display (Search)	2, 5, 8, 33
48	Check AND Display (Tracking)	2, 3, 5, 6, 8, 9, 13, 142, 143, 152, 153
49	Check Anticollision Light Switch	36, 110, 111
50	Check Anti-ice Control Switch	36, 140
51	Check Anti-ice Test Switch	33, 36, 111
52	Initialize APU	86, 129, 147
53	Check APU Control Switch	35, 36, 100

8. FUNCTION CROSS-REFERENCE

1	Acquire Target (DTV)	26
2	Acquire Target (Laser Spot Tracker, Automatic)	28, 31, 34
3	Acquire Target (Laser Spot Tracker, Manual)	27, 30, 33
4	Acquire Target (DVO)	29
5	EMPTY	
6	EMPTY	
7	Acquire Target (FLIR)	32
8	EMPTY	
9	EMPTY	
10	Activate Ignition	2
11	Adjust IHADSS Boresight (Gunner)	6
12	Adjust IHADSS Boresight (Pilot)	6
13	Adjust Outfront Boresight	7
14	Arrange Cockpit (Gunner)	4
15	Arrange Cockpit (Pilot)	4
16	Change Battle Position	18
17	Check Aircraft Systems (Gunner)	7, 8, 9, 10, 11, 12, 13, 16, 46
18	Check Aircraft Systems (Pilot)	8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 48, 49
19	Check Area Security (Sensor Search)	14, 15
20	Check Area Security (Visual Search)	14, 15
21	Check Armament Subsystems (Gunner)	2
22	Check Armament Subsystems (Pilot)	2
23	Check Cockpit Conditions (Gunner)	2
24	Check Cockpit Conditions (Pilot)	2
25	Check Collective Switches (Gunner)	4
26	Check Collective Switches (Pilot)	4
27	Check Engine 1 ECU Lockout System	6
28	Check Engine 2 ECU Lockout System	6
29	Check Engine Chop Circuit	6
30	Check Fuel Sample	3
31	Check Helmet (Gunner)	4
32	Check Helmet (Pilot)	4
33	Check Instrument Panel (Gunner)	4
34	Check Instrument Panel (Pilot)	4
35	Check Left Control Console (Gunner)	4
36	Check Left Control Console (Pilot)	4
37	Check Left Side - Fuselage and Nose	3
38	Check Left Side - Mast	3
39	Check Left Side - Rear Fuselage	3
40	Check Left Side - Wing	3
41	Check Overhead Panel	4
42	Check Right Control Console (Gunner)	4
43	Check Right Control Console (Pilot)	4
44	Check Right Side - Mast	3
45	Check Right Side - Rear Fuselage	3
46	Check Right Side - Under Fuselage	3
47	Check Right Side - Wing	3
48	Check Security Devices	2
49	Complete TAMMS Forms	52
50	Compute Fuel Burn Rate	9, 10
51	Conduct Postflight Walk Around	52
52	Consolidate Forces	15

APPENDIX G

dBASE FILE STRUCTURES FOR TOSS DATA

dBASE File	Field	Field Name	Type	Width	Description
MODEL.DBF	1	MODELNAME	Character	66	Model Name
	2	RANOCCUR	Logical	1	Controls the number of occurrences of random functions and tasks during simulation True = Random False = Fixed
	3	RANTIMES	Logical	1	Controls the start times of random functions and tasks during simulation True = Random False = Fixed
MODELOP.DBF	1	OP_CODE	Character	1	Crewmember Code
	2	OP_NAME	Character	8	Crewmember Name
MODELWL.DBF	1	WL_ABBRV	Character	3	Workload component abbreviation (the last record contains information about the workload equation)
	2	WL_NAME	Character	12	Workload component or equation name
	3	WLOL_MIN	Numeric	7	Workload component or equation overload threshold
	4	WLSPECS	Character	21	Workload component specifiers (not used in the equation record)
	5	CONFLICT	Character	20	Workload component specifier conflict pairs--up to 10 pairs (not used in the equation record)
	6	EQUATION	Character	66	Workload equation - only used in the equation (last) record of file
MODELSS.DBF	1	GROUPCODE	Character	1	Subsystem group code (only used at the beginning of each subsystem group)

dBASE File	Field	Field Name	Type	Width	Description
MODELSS.DBF (continued)	2	GROUPNAME	Character	30	Subsystem group name (only used at the beginning of each subsystem group)
	3	SSCODEMAX	Numeric	2	Number of subsystems in the group - indicates the number of records containing the subsystem information for that group
	4	SS_ABBRV	Character	3	Subsystem abbreviation
	5	SS_NAME	Character	30	Subsystem name
TASKDB.DBF	1	NUMBER	Numeric	4	Task number
	2	TASKNAME	Character	66	Task name
	3	SS1	Character	3	First subsystem associated with the task
	4	SS2	Character	3	Second subsystem associated with the task
	5	SS3	Character	3	Third subsystem associated with the task
	6	WL1	Numeric	5	First workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	7	SPEC1	Character	1	Workload specifier for the first workload rating
	8	WL2	Numeric	5	Second workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	9	SPEC2	Character	1	Workload specifier for the second workload rating
	10	WL3	Numeric	5	Third workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	11	SPEC3	Character	1	Workload specifier for the third workload rating

dBASE File	Field	Field Name	Type	Width	Description
TASKDB.DBF (continued)	12	WL4	Numeric	5	Fourth workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	13	SPEC4	Character	1	Workload specifier for the fourth workload rating
	14	WL5	Numeric	5	Fifth workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	15	SPEC5	Character	1	Workload specifier for the fifth workload rating
	16	WL6	Numeric	5	Sixth workload rating for the task. Component is determined by order of entry in MODELWL.DBF
	17	SPEC6	Character	1	Workload specifier for the sixth workload rating
FUNCTION.DBF	1	FUNCTION	Numeric	4	Function number
	2	NAME	Character	66	Function name
	3	FIXEDNUM	Numeric	4	Number of fixed tasks in the function decision rule - discrete fixed and continuous fixed
	4	CONT_RAN	Numeric	4	Number of continuous random tasks in the function decision rule
	5	DIS_RAN	Numeric	4	Number of discrete random tasks in the function decision rule
BLDFUN.DBF	1	FUNCTION	Numeric	4	Function number
	2	TASK	Numeric	4	Task number - Place all fixed tasks first, then continuous random tasks, followed by discrete random tasks

dBASE File	Field	Field Name	Type	Width	Description
BLDFUN.DBF (Continued)	3	OPERATOR	Numeric	1	Crewmember for the task - coded as a number corresponding to the order of crew as entered in MODELOP.DBF
	4	START	Numeric	7	Task start time
	5	FINISH	Numeric	7	Task finish time - only used for discrete random or continuous random tasks
	6	DURATION	Numeric	7	Task duration
	7	TIMES	Numeric	3	Number of occurrences of the discrete random task - only used for discrete random tasks
	8	DIS_FIX	Logical	1	Indicates class of fixed task: True = discrete False = continuous
SEGMENT.DBF	1	SEGMENT	Numeric	4	Segment number
	2	NAME	Character	66	Segment name
	3	FIXEDNUM	Numeric	3	Number of fixed functions in the segment decision rule - discrete fixed and continuous fixed
	4	RANDOMNUM	Numeric	3	Number of discrete random functions in segment decision rule
BLDSEG.DBF	1	SEGMENT	Numeric	4	Segment number
	2	FUNCTION	Numeric	4	Function number - Place all fixed functions first followed by discrete random functions
	3	DISCRETE	Logical	1	Indicates class of fixed function: True = discrete False = continuous
	4	START	Numeric	7	Function start time

dBASE File	Field	Field Name	Type	Width	Description
BLDSEG.DBF (Continued)	5	FINISH	Numeric	7	Function finish time - only used for discrete random functions
	6	DURATION	Numeric	7	Function duration
	7	FUN2	Numeric	4	Second function number - only used for discrete random functions
	8	DUR2	Numeric	7	Second duration - only used for discrete random functions
	9	TIMES	Numeric	3	Number of occurrences of the discrete random function
	10	INTRPT1	Numeric	4	Interrupt function number
	11	INTRPT2	Numeric	4	Interrupt function number
	12	INTRPT3	Numeric	4	Interrupt function number
	13	INTRPT4	Numeric	4	Interrupt function number
	14	INTRPT5	Numeric	4	Interrupt function number
	15	INTRPT6	Numeric	4	Interrupt function number
	16	INTRPT7	Numeric	4	Interrupt function number
	17	INTRPT8	Numeric	4	Interrupt function number
	18	INTRPT9	Numeric	4	Interrupt function number
	19	INTRPT10	Numeric	4	Interrupt function number
	20	INTRPT11	Numeric	4	Interrupt function number
	21	INTRPT12	Numeric	4	Interrupt function number
CLASHES.DBF	1	FUNCTION1	Numeric	4	First function number in clash pair
	2	FUNCTION2	Numeric	4	Second function number in clash pair

Please provide us with comments and suggestions about TOSS

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